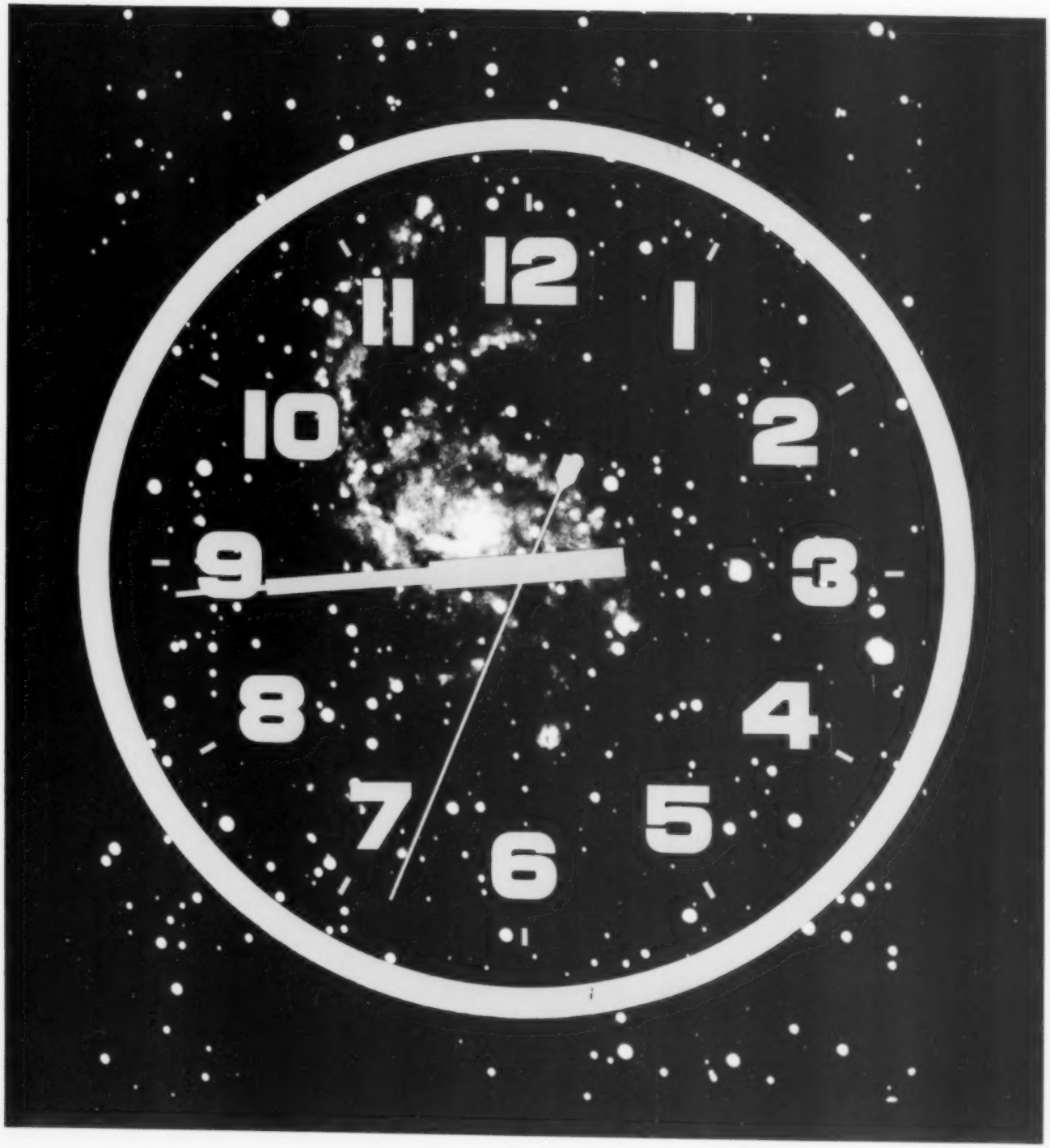
DIMENSIONS/NBS

The magazine of the National Bureau of Standards U.S. Department of Commerce

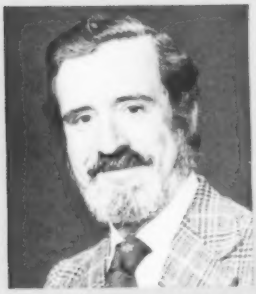
May 1978



TIME AND ASTRONOMY. See page 7.

COMMENT

MATERIAL DEGRADATION



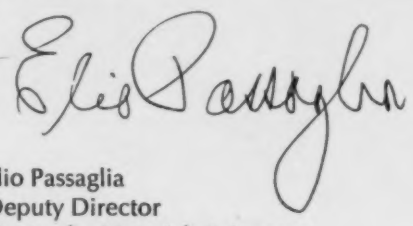
With great effort, considerable expense, and often significant personal danger, ores are mined from the earth to begin a life cycle of materials. In steel mills, smelting plants, chemical refineries, glass plants, and other such enterprises, a host of beautiful and useful materials that form the bones, sinews, and life-blood of our industrial society are processed from these ores: silvery, strong stainless steels; warm, malleable copper; opalescent polyethylene; ruddy, sturdy brick; glistening, shimmering glass, to name only a few of an almost endless list. From these materials there are manufactured a host of products, from airplanes to zippers, that are the tools and fixtures of our society and indeed, of any conceivable human society.

Unfortunately, when these materials are formed into products and then put to use, they are subject to a number of processes that limit their useful lifetime and, in many cases, cause them to revert to the ores from which they were derived. Foremost among the degradative mechanisms are corrosion, wear, fracture and fatigue, oxidation, ultraviolet degradation, mildew, and rot. To maintain the integrity of the materials and the products formed from them, we spend a great deal of effort to protect them, or at least we do so if we are wise. So we paint our houses, wax our cars, cathodically protect our pipelines, lubricate our motors, and so on. Nevertheless, despite our best efforts, our products eventually wear out. It is as if nature, angry at our wresting materials from ores, insists upon returning these materials to their natural state.

The processes that cause this degradation, while distinct in the technical mechanisms of their action, have one thing in common: they cost the economy money. This cost comes in two principal forms: in maintenance and protection, and in the shortened lifetime of equipment. The expense of maintenance and protection is easy to see; the cost of shortened lifetime (which, it turns out, is the far greater one) is more subtle. It means that our equipment has to be replaced more frequently than would otherwise be necessary. This happens even if we are wise and use the best affordable protective technology available. Unfortunately, we are not always wise, and hence incur costs that could be avoided if we were more knowledgeable and prudent.

The actual magnitude of these costs has been the basis of several studies. In all fields except corrosion, these studies have been of limited scope, and even in that field, until very recently, only one truly national study was available. This was the famous Hoar Report for Great Britain, which showed that the cost of corrosion in that country was about 3 percent of the gross national product, and that about one-quarter of this amount could be saved if everyone used the best affordable technology.

Concerned about the cost of corrosion in the United States, the Congress in 1976 directed the National Bureau of Standards to "embark upon a study of the economic effects of corrosion." This study has recently been completed, and a report has been sent to the Congress. This report concludes that the cost of corrosion to this country in 1975 was some $70 billion, about $10 billion of which could have been saved with available technology. This report will be featured in an article in next month's DIMENSIONS/NBS. Look for it—you may not know what you're spending for corrosion.



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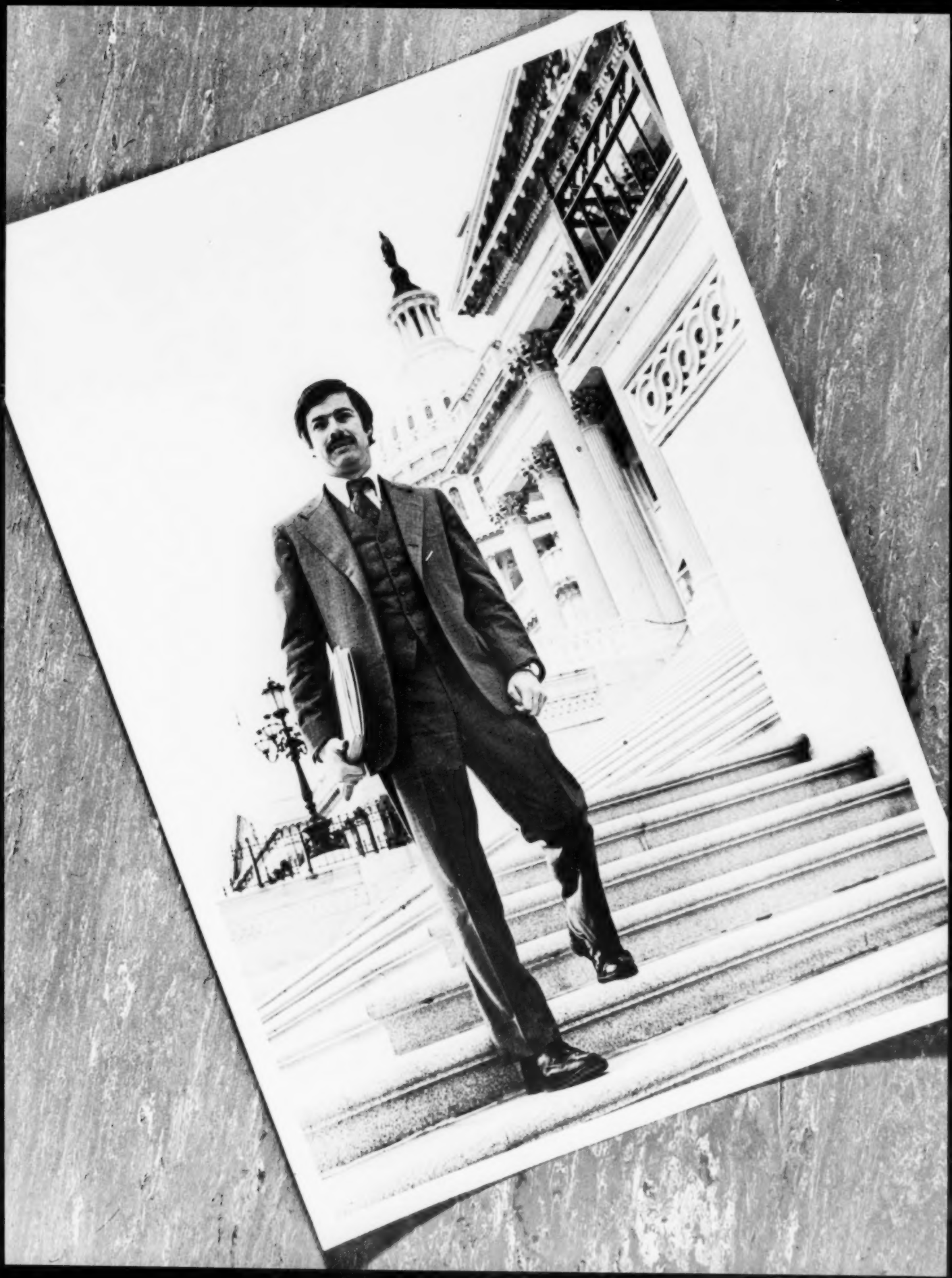

A Scientist on Capitol Hill

Few Americans get the opportunity to observe and take part in the inner workings of the United States Congress. Dr. Frederic Clarke of the National Bureau of Standards is one who did. Last year he participated in a special program that gives selected individuals the opportunity to take a leave of absence from their agencies or organizations and to serve in Congressional offices. In the following interview, Clarke, a chemist by training and a manager of scientific programs for several years, shares with the editor of DIMENSIONS some of the experiences and observations of a man who emigrated from his native research environment to what was, for him, the most "foreign" of lands—Capitol Hill.

Editor: I get the impression that you suffered a kind of culture shock during your first few weeks on Capitol Hill.

Clarke: Yes, As a matter of fact, about my third week on the Hill, I began to wish for a button to wear with words to the effect: "Scientists Are People, Too." I suppose I might have had one made, but I was concerned about a rejoinder like, "How do you know?"

Editor: Are you saying that members of Congress and Congressional staffers are hostile to scientists?

Clarke: No, not at all. They didn't see anything wrong with my being a scientist. It simply made me a kind of oddity—no cause for concern, just a bit unusual. Actually, it's not surprising that Congressional types regard technical types as novelties. There are only a few Congress-based practitioners of science and engineering. But, there are some programs that keep a small but steady stream of technical people moving among Congressional offices.

Editor: Later I want to come back to what you have just said—the fact that technically trained people are scarce on the Hill. I'm sure people would be interested in knowing what you think about this situation. But before we get into that, maybe you had better introduce yourself professionally to DIMENSIONS readers and give them some background on how you got to the Hill.

Clarke: Right now, I am acting director of the Center for Fire Research at the National Bureau of Standards. I came to NBS, in management, in 1974, but my degrees are in chemistry, and I have worked at the lab bench. In 1976 my boss nominated me for the Congressional Fellowship Program, which is sponsored by the American Political Science Association and the Civil Service Commission. I was accepted, and I served a total of 10 months in two different Congressional offices.

Under the Congressional Fellowship Program every year, a few executives inside and outside government get first hand experience with the Congress. The organization that employs the Fellow pays for the program. It's similar to a university sabbatical.

I am only one of several NBS employees who have participated in this program. Most of the Bureau people who spend time on the Hill get there by another route—the Commerce Department's Science and Technology Fellowship [ComSci] Program. Technical types, mainly from Commerce agencies, get the opportunity as "ComSci's" to work in another Executive Branch agency or in a Congressional office. The ComSci program is run by the Department's Assistant Secretary for Science and Technology.

In both programs, the theory is that by giving managers or people who have executive potential some experience outside their own arenas, they will broaden their perspective. This, in turn, is expected to benefit the "parent" organization.

"Time is the tyrant of the Congress."

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Clarke with Michael Naylor, legislative director for Senator John Culver.

Editor: Was your perspective broadened by your exposure to the workings of Congress?

Clarke: Definitely, but I hardly know where to start in explaining.

Editor: Could you tell us from your own experience what happens when someone becomes a Fellow?

Clarke: The first thing that happens to Fellows —Congressional or ComSci— can come as quite a shock. They get turned out practically on their own to peddle their skills and get themselves a job. This job hunting can be a real blow to the ego, but I guess it is supposed to be the first test of a person's resourcefulness.

I know it was in my case, at least. I am a reasonably presentable type, I think, but I didn't find much satisfaction in haunting the halls of Congress. Nineteen-year-old secretaries exuded charm one minute and turned into steely eyed fanatics the next minute, bent on keeping me from talking to anybody above the rank of dictaphone. Finally, the offers did start to come in, though, as they generally do. After all, Fellows are free help for the Congress, and we are generally fairly senior people with a good deal to offer. Knowing this doesn't help much, however, in the early stages of job hunting when you feel that you can't even give your skills away.

Editor: But you finally got a job. Where did you work?

Clarke: I was lucky enough to get a position first in the office of Senator John Culver from Iowa and then with Jim Wright from Texas, the House Majority Leader. The plan was that I would spend half my time with each of them, but I was called back to NBS early because the Bureau was undergoing a major reorganization. I had to cut short my stay with Wright.

I should explain that there are really two basic types of congressional office. One is that of the Senator or Representative—the personal staff—and the other is the office belonging to a committee. The standing committees in both Houses of Congress have their own staffs. In principle, these separate types concentrate on different things. The personal office is concerned with the member's legislative program—how he or she will vote and what bills will be sponsored—press relations, and the constituency—the attitudes and events back home. By contrast, the committee staff is concerned almost exclusively with the development of legislation—hearings, committee reports, and the various phases of a bill's progress through the committees.

Editor: What did you do in offices where you worked?

Clarke: In both the Senate and the House, I worked in the office of an elected official, not in a committee office. With Culver, I served as a legislative assistant. During my stay, we introduced two pieces of legislation concerning product liability insurance for small businesses. Senator Culver is a member of the Senate Small Business Committee, and his Iowa background gives him a particularly keen interest in the problems which confront the

small business community. People involved in many areas of small business feel that they are being hurt severely by the high and rising cost of insurance. The manufacturer can be held legally responsible for the safety of a product. Increasing numbers of court cases are being won by consumers who are injured while using a product. This drives up the cost of insurance, which virtually all small businesses must carry in order to operate. Studies show that it often makes no difference whether a business has been operating for 50 years without a single suit; they still have to pay what can be a prohibitively high price for insurance—if they can buy it at all.

Culver feels that Congress should ameliorate the situation. I arrived on the scene in time to get involved at the very beginning of the first piece of legislation.

Editor: Was it your job to give technical input based on your education and experience?

Clarke: Absolutely not. Neither bill has what a scientist would call a technical component, and neither does most legislation. What you really want to know, I think, is what kind of contribution a member of the technical community can make on the Hill. The answer turns upon whether one wishes to overhaul the system or to conform it. I chose to conform to it. That meant that, rather than trying to carry the lamp of scientific enlightenment to the U.S. Congress, my principal concern was to see how my interest fitted into the big picture as the Congress perceives it.

What I found out was that I, and many of my colleagues, tend to think of the technical aspects of a problem as the whole problem. In part this is a reflection of the fact that scientists are rarely elected to their jobs. I do feel that I had one contribution to make that relates directly to my technical education and experience: I could make good use of the problem-solving abilities I had developed through my discipline. Insofar as we are good problem-solvers, scientists and engineers have something to offer the Congress.

I applied this part of my training when I worked on the two product liability bills. The first bill would establish a federal re-insurance program so that the government would assume some of the insurance risk. Our intent is to see that the reputable small manufacturer would be able to get insurance, hopefully at a reasonable cost. It is intended as a stop gap measure only. The rationale for this is that we need some immediate relief for small business, but we also need a long-term solution.

The second bill would allow a manufacturer to set aside an insurance fund and take a tax write-off for it. As the tax law now stands, the manufacturer can claim a tax deduction for insurance premiums but is penalized comparatively for being self-insured. This is really a gross oversimplication of what the two bills are about, but I don't want to dwell too long on these details.

Editor: Has either bill become law?

Clarke: Not yet. Senator Culver introduced both bills while I was working as a Fellow, and they are still in committee. I will say that the day after Culver introduced the tax bill in the Senate, a Representative whose background is tax law decided to introduce essentially the same bill on the House side. I took this as a positive sign that our work was technically well grounded.

I don't want to give the impression that when I was with Culver I worked solely on legislation. My general assignment was to work on all matters pertaining to small business. As a result, I got involved in everything from answering constituent mail to writing speeches, drafting legislation, and working with the staff of the Small Business Committee.

When I was with Representative Wright, I was a liaison with his constituency. I arranged meetings, coordinated administrative activities, probed the interests and concerns of the people back home, and tried to develop ideas and strategies that would benefit the constituents.

Editor: You participated in the workings of both the House and the Senate. How do they compare?

Clarke: Naturally there are many similarities. The clock is the tyrant of the entire Congress. There is never enough time in a day. And going hand in hand with the problem of time is the impossibility of logistics. Virtually every weekday, a member of either House faces a morning of committee hearings, several of which are likely to be scheduled simultaneously. Floor sessions make up the balance of the day, with time squeezed out to visit with constituents who are in town, work with the staff on office business, make appearances and give speeches and interviews, get briefed on issues, eat, and sleep. Weekends will very likely find a member in the home state or district taking care of grassroots matters. And through all of this, the member has to steal some time to plan and reflect on it all. To a great extent this pace and its effects are shared by the staff.

As far as differences—there are very great differences between the staffs of Senators and those *turn page*

of Representatives. Representatives tend more to be specialists. Since there are over 400 of them, each one can afford to concentrate heavily on a few relatively small areas in the total scope of national problems. So one might become an expert on defense spending and another on transportation policy and the like. A fairly small personal staff follows the topics the Representative doesn't have time to attend to personally in great depth. Thus, it is common to see the universe of topics—defense, environment, health, and so on—divided among three or four legislative assistants.

By contrast, the Senator is inclined to be a generalist, serving on two or three major committees and, if a member of the majority party, chairing a subcommittee. There are a quarter as many Senators as Representatives, and it follows that the Senator is spread about four times as thin. For this reason alone—to compensate—the personal staff of the Senator is usually larger, and each assistant concentrates in depth on a narrower range of issues. Also, the logistics that surround relations with the home state are more complicated for the Senator—especially those from the states with big populations.

Editor: What was the biggest psychological adjustment you had to make when you changed from a research environment to the political arena?

Clarke: At NBS we measure talent primarily in intellectual terms. I had to re-evaluate and re-think things when I got to the Hill. It is just as difficult to follow the convoluted logic of a piece of legislation or to keep track of the parliamentary maneuvering of a colleague as it is to decipher a phase diagram. The intellectual meat in the former may be thinner, but it's often done after you've been on your feet for 16 hours.

To a remarkable extent in the Congress, success depends on physical and mental stamina. This is every bit as essential as intellectual candle power.

Editor: Now I would like to go back and ask you the question I deferred earlier. You have said yourself that scientists are treated as a novelty on the Hill because there are so few of them working there. Some members of the technical community seem to feel that there is both a lack of scientists and good scientific information on the Hill. What do you think?

Clarke: If there is a lack of good scientific information on the Hill, and I am not saying there is, it certainly isn't because there are so few scientists in residence. Any member of Congress has access to the very best information and advice. What noted scientist would refuse to consult with a Senator or a Representative? The best available scientific information is no further away than the telephone.

And I do want to qualify what I said earlier about scientists being scarce. This is true for personal staffs, but committees that deal with technical matters have technical experts on the staff.

I am not persuaded by the argument that more scientific advice on the Hill would result in better decision-making. But I am certainly persuaded that those in the Executive Branch who have to implement these decisions must have ready access to the best scientific expertise. In fact, successful implementation of much legislative policy depends on good science.

Editor: What, if anything, have you gained from your experience as a Congressional Fellow that you feel is of benefit to you and to the National Bureau of Standards?

Clarke: I am repeating myself, but I say again that I had to learn that the technical aspects of a problem are not the whole problem. This may sound simple, but it was a tremendous education and an important discovery for me. It brought me a different perspective on science in relation to the rest of society. Those of us who are directly involved in science are most nearly the custodians of basic research. It's ultimately up to us whether or not basic science grows and prospers—or continues at all. To see that it does, we have to learn the system. Considering the alternatives, there is nothing very wrong with that system. There is something wrong with the notion that it is up to the system to seek us out. □

Time & Astronomy

by James Jespersen and Jane Fitz-Randolph
(from their book titled *From Sundials to Atomic Clocks*)

We have seen that the measurement and determination of time are inseparably related to astronomy. Another facet of this relationship, which sheds light on the evolution of the universe and the objects it contains, has been revealed over the past few decades. In this chapter we shall see how theory combined with observations has allowed us to estimate the age of the universe. We shall discuss some "stars" that transmit signals like "clockwork," and we shall discuss a peculiar kind of star to which the full force of relativity theory must be applied if we are to understand the flow of time in the vicinity of such a star. And finally we shall discuss a new technique of radio astronomy that became possible only with the development of atomic clocks, and that has interesting applications outside of radio astronomy.

MEASURING THE AGE OF THE UNIVERSE

In 1648 Irish Archbishop Usher asserted that the universe was formed on Sunday, October 23, 4004 B. C. Since then there have been numerous estimates of the age of the universe, and each new figure places the origin back in a more distant time. In the 19th Century, Lord Kelvin estimated that it had taken the earth 20 to 40 million years to cool from its initial temperature to its present temperature. In the 1930's, radioactive dating of rocks settled on two billion years, and the most recent estimates for the age of the universe lie between 10 and 20 billion years.

These newest estimates are developed along two lines of thought and observation: The first relates the age of the universe to the speeds, away from the earth, of distant galaxies. The second is obtained from observations of the makeup of the universe that peg it as being at a particular point in *time* along its evolutionary "track."

The Expanding Universe—Time Equals Distance

Throughout much of history, man has tended to think of the universe as enduring "from everlasting to everlasting." But in 1915 Einstein applied his theory of general relativity to the problem of the evolution of the universe and reluctantly came to the conclusion that the universe is dynamic and expanding. In fact, he was so dubious about his conclusion that he introduced a new term into his equations—the "cosmological term"—to prevent his equations from predicting this expansion. Then in 1929, some 14 years later, the American astronomer Edwin Hubble discovered that the universe was indeed expanding, and Einstein is reported to have said that the cosmological term was "the biggest blunder of my life."

COVER STORY

Jespersen is a researcher in the Time and Frequency Division of the National Bureau of Standards. Fitz-Randolph teaches writing at the University of Colorado. Their book is about—time. What could be simpler than time? Almost everything, the reader will discover. But making that discovery is as easy and entertaining as it is informative. The discussion skillfully covers the mundane (ordinary clocks) as well as the mysterious (the black holes of space). Order from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402. Order prepaid ($4.00). Use Stock No. 003-003-01650-1.

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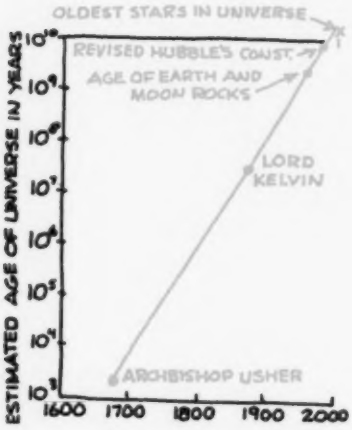


HUBBLE'S DISCOVERY

We have already encountered the technique used by Hubble to discover the expanding universe. It is based on the Doppler effect, whereby the whistle of an approaching train seems to have its frequency shifted upward, and then shifted downward as the train moves away. Hubble was investigating the light from a number of celestial objects when he noticed that certain aspects of the light spectrum were shifted to lower frequencies, as though the radiating objects were moving away from the earth at high speeds. Furthermore, the more distant the object, the greater its speed away from the earth.

With Hubble's discovery of the relationship between distance and speed, it was possible to estimate an age of the universe. The fact that all objects were moving away from the earth meant that all celestial objects had at some time in the distant past originated from one point. The observed distance to the objects, with their corresponding recessional speeds, when extrapolated backward in time, indicated an origin about 20 billion years ago. Of course, we might suspect that the recessional speeds have been slowing down with time; so the age of the universe could be less than that derived from the presently measured speeds. In fact, using the evolutionary line of reasoning to estimate the age of the universe, we find that this seems to be the case.

Big Bang or Steady State?

Scientists have developed theories for the evolution of the universe. And according to these theories, the universe evolves in a certain way, and the constitution of the universe at any point in time is unique. From the observations to date, it would appear that the universe is about ten billion years old, which fits in with the notion that the universe was, at an earlier date, expanding at a greater rate than it is today. This theory is known popularly as the "big bang" theory. It postulates that at the origin of time, the universe was concentrated with infinite density and then catastrophically exploded outward, and that the galaxies were formed from this primordial material.

Competing with this theory is the so-called "steady state" theory, which is more in line with the philosophical thought that the universe endures "from everlasting to everlasting." But the great bulk of the astronomical observations today agrees with the big bang theory rather than the steady-state theory, and the steady state theory has been largely abandoned.

Of course, we are still faced with the unsettling question of what about before the big bang. We do not have the answer. But perhaps the reader will have realized by this point that time has many faces, and perhaps in the long run questions of this sort, relating to the ultimate beginning and end of the universe, are simply projections of our own micro experience into the macroworld of a universe that knows no beginnings and no ends.

STELLAR CLOCKS

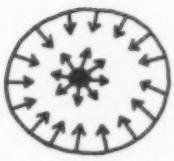
Quite often in science a project that was intended to explore one area stumbles unexpectedly upon interesting results in another. Several years ago, a special radio telescope was built at Cambridge University's Mullard Radio Observatory in England, to study the twinkling of radio stars—stars that emit radio waves. The twinkling can be caused by streams of electrons emitted by the sun. It may be quite fast, so equipment was designed to detect rapid changes.

PULSAR SIGNAL

In August of 1964, a strange effect was noticed on a strip of paper used to record the stellar radio signals: There was a group of sharp pulses bunched tightly together. The effect was observed for over a month and then disappeared, only to reappear. Careful analysis indicated that the pulses were coming with incredible regularity at the rate of 1.33730113 per second, and each pulse lasted 10 to 20 milliseconds. Such a uniform rate caused some observers to suspect that a broadcast by intelligent beings from outer space had been intercepted. But further observations disclosed the presence of other such "stellar clocks" in our own galaxy—the Milky Way Galaxy—and it did not seem reasonable that intelligent life would be so plentiful within our own galaxy.

It is generally believed now that the stellar clocks, or *pulsars* as they are called, are neutron stars, which represent one of the last stages in the life of a star. According to the theory of the birth, evolution, and death of stars, stars are formed from interstellar dust and gas that may come from debris left over from the initial "big bang" or from the dust of stars that have died in a violent explosion or "super nova."

A particular cloud of gas and dust will begin to condense because of the mutual gravitational attraction between particles. As the particles become more compact and dense, the gravitational forces increase, forming a tighter and tighter ball, which is finally so dense and hot that nuclear reactions, like a continuously exploding H bomb, are set off in the interior of the mass.



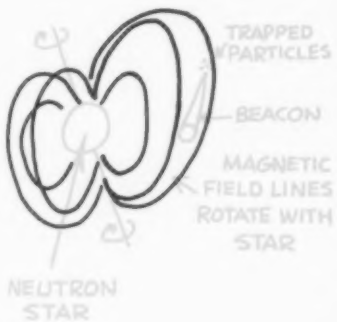
White Dwarfs

In a young star, the energy of heat and light is produced by the nuclear burning of hydrogen into helium. The pressure generated by this process pushes the stellar material outward against the inward force of gravitation. The two forces struggle against each other until a balance is reached. When the hydrogen is exhausted, the star begins to collapse gravitationally upon itself again, until such a high pressure is reached that the helium begins to burn, creating new and heavier elements. Finally, no further burning is possible, no matter what the pressure, and the star begins to collapse under its own weight.

At this point, what happens to the star depends upon its mass. If its mass is near that of our own sun, it collapses into a strange kind of matter that is enormously more dense than matter organized into the materials we are familiar with on earth. One cubic centimeter of such matter weighs about 1000 kilograms. Such a collapsed star is called a "white dwarf," and it shines faintly for billions of years before becoming a "clinker" in space.

Neutron Stars

For stars that are slightly more massive than our sun, the gravitational collapse goes beyond the white dwarf stage. The gravitational force is so great and the atoms are jammed together so closely that the electrons circling the core of the atom are pressed to the core, joining with the protons to form neutrons with no electrical charge. Normally, neutrons decay into a proton, a massless particle called a neutrino, and a high-speed electron, with a half-life of about 11 minutes—that is, half of the neutrons will decay in 11 minutes. But given the enormous gravitational force inside a collapsed star, the electrons are not able to escape, and thus we have a "neutron star"—a ball about 20 kilometers in diameter, having a density a hundred million times the density of a white dwarf. Such an object could rotate very fast and not fly



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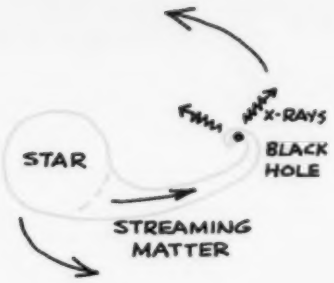
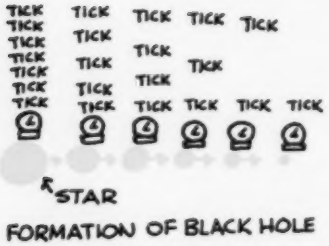




apart, and it looks as though the neutron star is the answer to the puzzling "stellar clocks."

But where do the pulses come from? Such a neutron star will have a magnetic field that rotates with the star, as the earth's magnetic field rotates with the earth. Electrically charged particles near the star will be swept along by the rotating magnetic field; and the farther they are from the star, the faster they will have to rotate—like the ice skater on the end of a "crack the whip" chain.

The most distant particles will approach speeds near that of light, but according to the relativity theory no particle can exceed the speed of light. So these particles will radiate energy to "avoid" exceeding the speed of light. If the particles are grouped into bunches, then each time a bunch sweeps by, we will see a burst of light or radio energy as though it were coming from a rotating beacon of light. Thus the pulses we detect on earth are in reality the signals produced as the light sweeps by us. If such an explanation is correct, then the star gradually loses energy because of radio and light emission, and the star will slow down. Careful observations show that pulsar rates *are* slowing down gradually, by an amount predicted by the theory.

Black Holes—Time Comes to a Stop

Stars with masses about that of our own sun or smaller collapse into white dwarfs; slightly more massive stars collapse into neutron stars. Now let's consider stars that are so massive that they collapse into a point in space.

In the case of the neutron star, complete collapse is prevented by the nuclear forces within the neutrons, but with the more massive stars, gravitation overcomes even the nuclear forces; and according to the theories available today, the star continues to collapse to a point in space containing all of the mass of the original star, but with zero volume, so that the density and gravity are infinite—gravity is so strong near this object that even light cannot escape; hence the term *black hole*.

These fantastic objects—black holes—were postulated theoretically, utilizing relativity theory, in the late 1930's; and within the last few years the evidence is mounting that they do indeed exist. One such observation reveals a star circling around an invisible object in space. In the vicinity of this unseen star, or black hole, strong x-rays are emitted, and it is suspected that these x-rays are generated by matter streaming into the black hole—matter that the gravity field of the black hole pulls away from the companion star.

How would time behave in the vicinity of such a strange object? We recall from our section on relativity (page 125) that as the gravitational field increases, clocks run more slowly. Let's apply this idea to a black hole. Suppose we start out with a massive star that has exhausted all fuel for its nuclear furnace and is now beginning to undergo gravitational collapse.

We'll suppose that on the surface of this collapsing star we have an atomic frequency standard whose frequency is communicated to a distant observer by light signals. As the star collapses, the frequency of the atomic standard, as communicated by the light signal, would decrease as the gravitational field increases. Finally, the size of the star reaches a critical value where the gravitational pull is so strong that the light signal is not able to leave the surface of the star.

Our distant observer would notice two things as the star approaches this critical size: First, the clock on the surface of the star is running more and more slowly; and at the same time, the image of the star is getting weaker. Finally we are left with only the "Cheshire cat smile" of the star.

A careful mathematical analysis of the situation shows that for the distant observer, it appears to take infinite time for the star to reach this critical size; but for an observer riding with the clock on the surface of the star, the critical size is reached in a finite length of time.

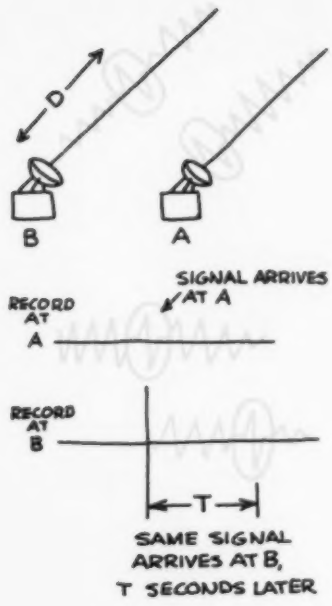
What does all of this mean? No one knows for sure. The equations indicate that the massive star just keeps collapsing on itself until it is merely a point in space. Mathematicians call these points in space *singularities;* and when a singularity is encountered in a mathematical law of nature, it means that the theory has broken down and scientists start looking for a more powerful theory that will lead them into new pastures. It has happened many times before in physics. For example, when Niels Bohr postulated that an electron could circle around an atom without spiraling into the nucleus, he provided a stepping-stone toward a whole new concept of the micro-world. Perhaps the "black hole" is the doorway connecting the micro-world to the macro-world.

TIME, DISTANCE, AND RADIO STARS

In Chapter 12 we described systems for determining distance and location from synchronized radio signals. Here we shall discuss a new technique for relating time to distance via observations of radio stars—a technique that has grown out of the relatively new science of *radio astronomy*.

One of the problems of astronomy is to determine the direction and shapes of distant celestial objects. Astronomers refer to this as the "resolution" problem. The resolution of a telescope is primarily determined by two factors—the area of the device that collects the radiation from outer space, and the radiation frequency at which the observation is made.

As we might expect, the bigger the collecting area, the better the resolution; but not so obvious is the fact that resolution decreases as we make observations at lower frequencies. For optical astronomers the area of the collecting device is simply the area of the lens or mirror that intercepts the stellar radiation. And for radio astronomers it is the area of the antenna—quite often in the shape of a dish—that figures in the determination of resolution.

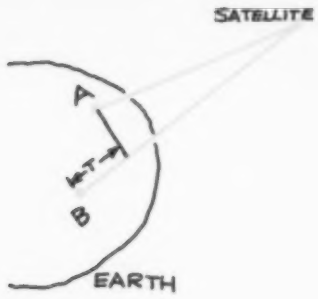


Because of the dependence of resolution on frequency, an optical telescope lens with the same area as a radio telescope dish yields a system with much greater resolution because optical frequencies are much higher than radio frequencies. The cost and engineering difficulties associated with building large radio antennas, to achieve high resolution at radio frequencies, fostered alternative approaches. A system consisting of two small antennas separated by a distance has the same resolution as one large antenna whose diameter is equal to the separation distance. Thus, instead of building one large antenna ten kilometers in diameter, we can achieve the same resolution with two smaller antennas separated by ten kilometers.

But as always, this advantage is obtained at a cost. The cost is that we must very carefully combine the signals received at the two smaller dishes. For large separation distances, the signals at the two antennas are typically recorded on magnetic tape, using high-quality tape recorders.

It is important that the two signals be recorded very accurately with respect to time. This is achieved by placing at the two antenna sites synchronized atomic clocks that generate time signals recorded directly on the two tapes along with the radio signals from the two stars. With the time information recorded directly on the tapes, we can at some later time bring the two tapes together—usually to a location where a large computer is available—and combine the two signals in the time sequence in which they were originally recorded. This is important, for otherwise we will get a combined signal that we cannot easily disentangle.

It is also important that the radio-star signals be recorded with respect to a very stable frequency source; otherwise, the recorded radio-star signals will have variations, as though the radio telescopes were tuned to different frequencies of the radio star "broadcast" during the measurement. The effect would be similar to trying to listen to a radio broadcast while someone else was continually tuning to a new station. The atomic standard also provides this stable frequency-reference signal. These requirements for time and frequency information are so stringent that the two-antenna technique, with large separation distance, is not practical without atomic clocks.



To understand the implications of this technique for synchronization and distance measurement, we need to dig a little more deeply. In the sketch, we see a signal coming from a distant radio star. Signals from radio stars are not at one frequency, but are a jumble of signals at many frequencies; so the signal has the appearance of "noise," as shown in the sketch.

Let's now consider a signal that is just arriving at the two antennas. Because the star is not directly overhead, the signal arriving at antenna A still has an extra distance, D, to travel before it reaches antenna B. Let's suppose that it takes the signal a time, T, to travel the extra distance, D, to antenna B. Thus we are recording the signal at A, a time T before it is recorded at B. The situation is similar to recording a voice transmission from a satellite at two different locations on the earth. Both locations record the same voice transmission, but one transmission lags behind the other in time.

Let's replace the radio star with a satellite. Suppose we know the locations of the satellite and the two earth sites, A and B, as shown in the sketch. We record the two voice transmissions on tape, and later bring the two recordings together and play them back simultaneously. We hear two voices, one being the "echo" of the other.

Now suppose that we have a device that allows us to delay the signal coming out of tape recorder A by an amount that is accurately indicated by a meter attached to the delay device. We adjust the delay from tape recorder A until the two voice signals are synchronized—that is, until the echo has disappeared. The amount of delay required to bring the two voices into synchronism is precisely the delay, T, corresponding to the extra distance the signal must travel on its way to antenna B, with respect to antenna A.

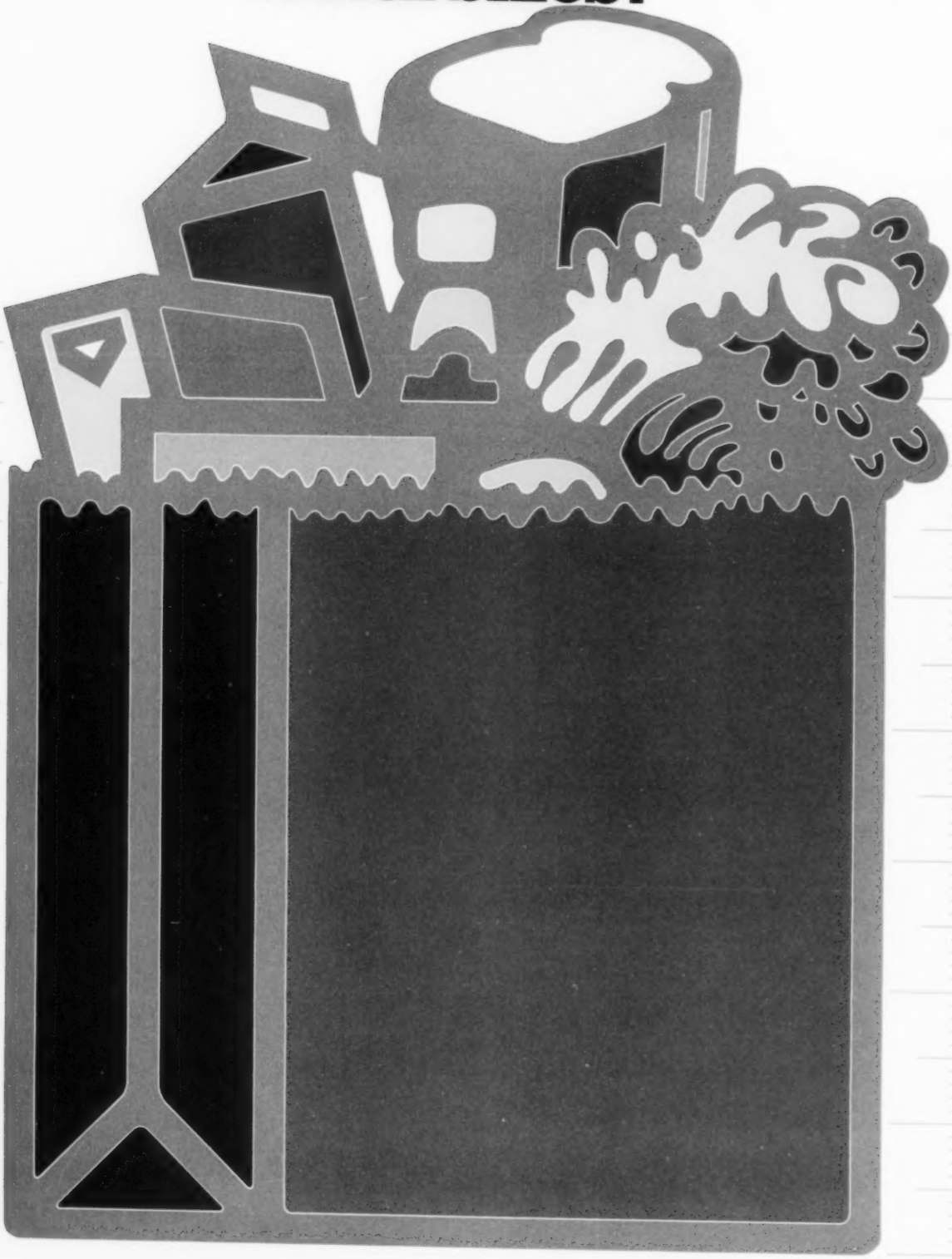
We stated that we knew the locations of the satellite and of A and B. This is enough information to calculate T. Suppose T is calculated to be 100 nanoseconds, but that the delay we measure to get rid of the echo is 90 nanoseconds. We are now confronted with a problem. Either the locations of the satellite and of A and B that we used to calculate T are in error, or the atomic clocks at A and B are not synchronized.

We recheck and find that the ground stations and satellite positions are not in error. Therefore, we conclude that the 10 nanoseconds error is due to the fact that the clocks are not synchronized. In fact, they must be out of synchronization by 10 nanoseconds. We now have a new means of synchronizing clocks.

We can also turn this situation around. Suppose we know for certain that the clocks are synchronized, and we also know the position of the satellite accurately. By combining signals recorded at A and B, we can determine what the A-B separation must be to give the measured time lag. Work is now underway to utilize just such techniques—but with radio stars instead of satellites—to measure the distance between distant parts of the surface of the earth to a few centimeters. Such measurements may give new insight into earth crust movements and deformations that may be crucial for the prediction of earthquakes.

The uses to which the relationships of time, frequency, and astronomy may be put are far reaching, and we probably have seen only the beginning.

Metric Milk and Bread: What Sizes?



by Jeffrey V. Odom

SOONER or later, as the United States moves to the metric system, metric sizes of consumer goods will become predominant in the marketplace. Some items, of course, have been metric for a long time: film and vitamins, for example. Others have converted recently: wine and distilled spirits, flowers and vegetable seeds, and some soft drinks. Most remaining products show metric equivalents on the labels of current "inch-pound" sizes. To insure that shoppers are able to make rational decisions during the time when metric usage and metric sizes are increasing, some guidelines for change are essential.

Actually, packages—their sizes and their labels—have long been regulated by federal, state, and even some local governments. The rationale for such regulation is explained in the federal Fair Packaging and Labeling Act of 1966:

"Informed consumers are essential to the fair and efficient functioning of a free market economy. Packages and their labels should enable consumers to obtain accurate information as to the quantity of the contents and should facilitate value comparisons. Therefore, it is hereby declared to be the policy of the Congress to assist consumers and manufacturers in reaching these goals in the marketing of consumer goods." (*Section 2*)

The changeover to metric will not violate this basic principle. However, situations will arise that require special consideration if consumers are to continue to be able to make value comparisons with ease.

Affected Laws and Regulations

There are numerous federal, state, and local laws and regulations that relate to packaging. These not only control label information but in many cases specify the sizes in which certain commodities may be sold. If voluntary metric conversion is to succeed, individuals and industries must not be prevented from making reasonable efforts to go metric. Specifically, laws and regulations should not discourage or prohibit the transition to metric sizes in packages.

• Federal Law

The primary federal law in this area is the one already cited—the Fair Packaging and Labeling Act (FPLA). This Act makes it:

"Unlawful for any person engaged in the packaging and labeling of any consumer commodity to distribute or cause to be distributed in commerce any commodity if such commodity . . . is contained in a package, or if there is affixed to that commodity a label, which does not conform to the provisions of this act." (Section 3)

Briefly, the act requires clear statements of the identity of the commodity, the name and address of the manufacturers, packer, or distributor, and the quantity of contents for all consumer goods. It prohibits metric-only packaging.

The enforcement of this act is the responsibility of the Food and Drug Administration for food, drugs, or cosmetics; and the Federal Trade Commission for other consumer commodities. Both agencies issue rulings or interpretations on what is or is not a consumer good. For example, FTC has ruled that paint is not a consumer good.

• State and Local Regulations

Regulations for labels on consumer goods not covered by FPLA and on non-consumer goods, and regulations relating to the sizes of certain commodities, are handled at the state and local government level. Since there are innumerable jurisdictions involved, uniformity is achieved through the National Conference on Weights and Measures, sponsored by the Natural Bureau of Standards' Office of Weights and Measures. The Conference was founded by NBS in 1905, and has among its objectives:

—To develop a consensus on model weights and measures laws and regulations.

—To encourage and promote uniformity of requirements and methods among weights and measures jurisdictions.

Model laws and regulations are developed by the National Conference in fulfillment of these objectives. They are, in turn, adopted as law by most states and sometimes by local jurisdictions. In the area of packaging, there are two such regulations: the Model State Packaging and Labeling Regulation (it parallels the FPLA in its goals and extends them into nonconsumer goods as well) and the Model State Method of Sale of Commodities Regulation (it prescribes specific, customary sizes for some consumer goods such as dairy products, bread, and flour).

Changes in Laws and Regulations

Revisions in a timely manner of these laws and regulations are essential, as stated above, to allow voluntary conversion to metric to proceed as desired. Specifically, changes are needed to allow:

• Metric-only labels and to regulate when they may appear in the marketplace as well as to ensure

turn page

Odom is metric coordinator for the National Bureau of Standards.

that dual declarations, when used, are understandable;

- Common sense, simple-number metric sizes for those items covered by such regulations. It is now illegal in many states to sell one liter of milk or a one kilogram loaf of bread because sizes are regulated according to customary measurements—quarts and pounds.

New Metric Sizes: What Should They Be?

Perhaps the major issue in packaging, once a company decides to go metric, is the one related to the size of the new metric package. There are two basic approaches that can be followed: "soft" conversion (simply expressing the old customary size in terms of metric units) and "hard" conversion (changing the size of the package so that it is in a simple metric size). The basic advantage of a soft conversion is that packaging machinery is not affected since the physical size of the package does not change. The disadvantage of soft conversion is that the numbers are more complex and awkward for consumers (for example 454 grams instead of one pound.) For hard conversion, the opposite is true: the major advantage is an easy to handle even number; the major disadvantage is that changes to packaging machinery must be made.

The basic consideration from the consumer's viewpoint is a tradeoff between the simplicity of a common sense set of simple, rounded metric sizes, with an accompanying ease of value comparison, and the possible expense of changes to machinery. Given the complexity and wide variety of machinery in use, certainly no general rules can be developed to make this decision. In most cases, special consideration will have to be given to each type of product.

Once a decision has been reached to go to "hard" metric packages, the specific sizes and size range selected become a major issue. This is an important consideration, since the decisions affect the number of sizes available (for example, "Can I buy a convenient size for my family?") In most cases, it is not now possible to predict what the new sizes will be.

Milk, for example, will probably be sold in even liter sizes. Bread, however, may go from one pound (454 gram) loaves to 400, 450 or maybe 500 gram sizes. This will be decided by the bakery industry with input from machinery suppliers, retailers, and consumers.

A related issue, once new metric sizes are selected and being introduced, is whether or not to allow concurrent sale of old, nonmetric sizes, and if so, for how long. From the standpoint of consumer value comparison, the ideal situation would be for all sources of a given commodity to be changed to new metric sizes at the same time. Since that is likely to be impractical if not impossible, dual labels should be required as long as there are nonmetric sizes of any given commodity on the market. In addition, a procedure will need to be developed to reach a consensus date after which, for each commodity, metric sizes must be used, with customary equivalents permitted as long as desired by the packager/manufacturer.

Dual Labels

As metric usage has been steadily growing in the United States, many consumer commodity labels have included equivalent metric values as a supplementary quantity statement. These have generally been simply soft conversions of the existing customary size.

From the consumer's point of view, this procedure is not an effective way to teach the metric system.* Undoubtedly, a little metric *awareness* is achieved,

*See *Exploding a Metric Myth: Down With Dual Usage*, DIMENSIONS/NBS, March 1978.

but this is probably negated by the reaction to what is usually an odd size ("1 quart, 0.946 liter"). Consumers will likely learn metric easily enough when necessary, but that will occur only when the familiar customary units are not displayed. And most certainly, consumers will learn more easily and more willingly when single numbers (1 liter instead of 0.946 liter) are used.

Nevertheless, dual labels will be useful when single metric sizes are first being introduced ("1 liter, 1.057 quarts"). Their use in this way, along with point-of-sale information, will enable consumers to compare prices of the new and the old sizes and to compare the differences in the sizes. However, since the use of dual labels might actually hinder the learning and acceptance of metric, cut-off dates for use of such labels will need to be established when all brands of a commodity have switched to metric.

One additional consideration with respect to dual labels is important: the accuracy used in the calculation of equivalent values. Too much accuracy (that is, converted values carried to too many decimal places) is not desirable because it makes the label confusing and the metric units appear awkward. In addition, when such values are rounded off, uniform guidelines must be followed to avoid confusion by the consumer of an unfair situation between competitors (e.g., if one firm gave the equivalent of one pound, which is actually 453.6 grams, as 453 grams and others gave 454 grams.

The National Bureau of Standards has proposed the following rule for dual labels and rounding, to appear in the Model State Packaging and Labeling Regulation. It states:

"In all conversions for the purpose of showing an equivalent metric or customary quantity to a rounded customary or metric size, the number of significant digits retained should be such that accuracy is neither sacrified nor exaggerated. As a general rule, converted values should be rounded down by dropping any digit beyond the first three."

Consumer Education: Avoiding Deception

There is a basic need for a comprehensive program to be developed to help consumers overcome their quite natural fear of the new and untried metric system. Much of this could be carried out using the retail food store as a classroom, since the average American consumer shops at least once a week for food. These stores will offer most Americans both a convenient and a continuous means of learning the metric system.

Packagers can assist in this effort by, among other things, indicating new metric sizes on packages in a highly visible place. Proper units and symbols should be used. (One recent survey disclosed twelve different ways of identifying a "gram.") More importantly, the new metric sizes should be slightly larger than current sizes rather than slightly smaller, if at all possible. Experience has already shown that consumers would prefer to pay more for a slightly larger size than pay the same for a slightly smaller package. This would be likely for a smaller size because packaging and handling costs would be the same.

Packagers are not alone in the need to assist. Advertisers should avoid unclear advertisements, should stress the new sizes, and could include educational material about the new sizes as well. Retailers can assist by having concise, clear and accurate point of sale information in a visible location for their shoppers. Retailers are also urged to exhaust existing supplies before placing new metric packages on the shelves.

All of these actions should provide adequate information for the protection of the consumer—regardless of what the new sizes will be. Further, they will ensure that consumers will be able to continue to make adequate value comparison, as intended by the President and the Congress with the enactment of the Fair Packaging and Labeling Act, and by the National Bureau of Standards and all state and local weights and measures officials with the promulgation of the various model regulations. Only in this way can we win and keep the support of the American public in the move to metric. □

NBS RESEARCH ASSOCIATE MAURICE DUCLOUX: THE FRENCH CONNECTION

by David Chaffee

The French connection in the National Bureau of Standards' Research Associate Program* is Maurice Ducloux, a French chemist who came to the Bureau's Center for Fire Research in September 1976 and whose visit has been extended through June 1978. Ducloux is employed by Rhone-Poulenc Industries, the largest chemical company in France.

While NBS Research Associates are primarily employees from American businesses, Ducloux adds a "special flavor" to the program, according to Industrial Liaison Officer Peter de Bruyn. For his part, Ducloux thinks NBS is "one of the best places in the world to conduct fire research." He explains that America is more prone to fires than other countries and is currently channeling considerable resources into fire research to reverse that trend. (The United States has the second highest fire fatality rate in the world, with 35 deaths per million annually.)**

Ducloux's research at NBS involves two related technical projects. Working with Clayton Huggett, chief of the Center for Fire Research's Office of Extramural Research, Ducloux is testing the effect oxygen concentration in the environment has on the fire behavior of polymers. Polymers are being used increasingly in buildings and furnishings, and the behavior of these materials in fires is a matter of growing concern.

In this effort, Huggett and Ducloux are employing an oxygen-index apparatus, in which a polymer stick in a pyrex cylinder is lit in a flowing mixture of oxygen and nitrogen gas, and the burning rate measured.

"The results thus far have shown that oxygen plays an important role in the ignition of and surface flame spread over polymers, but that the concentration of oxygen above a critical lower limit is not important to steady state burning," says Huggett. Results of the project will be detailed in a paper Ducloux and Huggett will co-author this year.

Ducloux's second project, under the direction of Richard Gann, chief of the Center for Fire Research's Program for Chemistry, has been to try to correlate results of various testing methods used in measuring the thermostability and fire behavior of polymers. This is being accomplished by subjecting nine sample polymers to a variety of tests and analyzing the results by computer. The purpose is to ascertain how well the stability of polymers relates to a variety of fire-related properties. Correlating results of testing methods may also reveal that some tests are merely duplicating others.

"There are many, many tests used to determine the fire behavior of a polymer," says Ducloux. "Certain tests used in one country may be totally different from those used somewhere else. What we need are the most meaningful tests."

Gann agrees, saying that current small scale tests empirically tell us something about a given polymer, but not enough to make it possible to extrapolate the results to other situations. Therefore, these methods cannot at present be used to predict actual fire behavior.

"One way to get information on a large number of polymers of the same generic type is to run a series of tests on each one. A better way is to know the basic properties that determine the fire behavior of polymeric materials and the structure of each candidate so you can predict results after testing only a few," Gann explains. Thus, knowing the basic properties, scientists can develop sound test methods and eliminate expensive, time-consuming trial and error techniques.

Research Associate Maurice Ducloux (left) and the Bureau's Richard Gann use the oxygen-index test to examine the properties of a polymer in a Center for Fire Research laboratory. Ducloux and Gann are examining testing methods such as the oxygen-index to determine how effective testing methods are in measuring the fire behavior of polymers.

Knowing the basic properties that govern a material's fire behavior may lead to appropriate measures for making materials more nearly fire safe. And, as Ducloux says, "Knowing these properties in the laboratory means that we will only have to conduct a limited number of full scale tests—burn down buildings—to learn how fires start and progress."

In addition to his laboratory work, Ducloux acts as an international communicator by staying informed about the various programs going on at the Center for Fire Research and relaying findings to Rhone-Poulenc Industries and the French Government.

"Communication between countries about fire research is essential," he says. "Efforts in one nation may complement work somewhere else. Also, there are differences in what is emphasized from country to country." For example, wooden homes in the U.S. flourish while there are very few in France. Consequently the fire behavior of wood has been studied much more extensively in the U.S. than in France."

Ducloux adds, however, that "We have many common goals, including the general study of the fire behavior of different materials. Determining basic properties of the materials is the only true way that solid international fire behavior standards can be developed. And this Research Associate Program may take us a good way towards establishing these standards."

Chaffee is a staff writer for DIMENSIONS/NBS.

**The Research Associate Program has brought researchers from all areas of industry to NBS labs for over 50 years to work on projects of mutual interest—for mutual benefit. For information, contact P. R. de Bruyn, Industrial Liaison Officer, Room A402, Administration Building, National Bureau of Standards, Washington, D.C. 20234. Phone: (301) 921-3591.*

***America Burning*, The National Commission on Fire Prevention and Control, 1973.

GROUP FORMED ON ELECTROMAGNETIC INTERFERENCE

by Frederick P. McGehan

Members of standards-writing committees who are grappling with the problem of electromagnetic interference (EMI) have agreed to form an umbrella committee to discuss mutual interests.

The decision came at a March 21 meeting at the National Bureau of Standards laboratory in Boulder, Colorado. The meeting was convened under the sponsorship of NBS and the Society of Automotive Engineers (SAE).

It marked the first time that members of EMI standards committees within SAE, the Motor Vehicle Manufacturers Association (MVMA), and the Electronic Industries Association (EIA) were brought together to discuss common problems of writing interference standards. "I think it was a very successful meeting," said Myron L. Crawford of NBS' Electromagnetic Field Division, who chaired the session.

The decision to form an umbrella group means that engineers representing the automotive, aerospace, defense, and consumer electronics industries will attempt to reach consensus on policy and language for measuring EMI. Until now, standards-writing committees have worked separately on their own parochial EMI problems.

The problem of electromagnetic interference is growing in both size and complexity as more and more industries switch from mechanical and hydraulic control systems in the products to integrated circuits, microprocessors and other electronic components.* By some estimates, the automobile industry alone is expected to spend as much as $1 billion for electronic controls between now and 1981.

More than 100 representatives of various industry associations and standards commitees attended the NBS-SAE meeting. Represented were the Electronic Industries Association, the Motor Vehicle Manufacturers Association and the Institute for Electrical and Electronics Engineers, in addition to SAE and NBS.

The representatives also decided to publish a newsletter to keep members of interested associations and committees informed of issues and meetings.

"It is important for us to have cross fertilization," stated Jack Moe, chairman of the SAE AE-4 subcommittee which sets standards for the aerospace industry.

The attendees agreed that, while the umbrella committee might work to establish test procedures for electromagnetic measurement, the actual test limits will continue to be set by the individual standards-writing committees.

The umbrella committee would also act as a clearinghouse for data that describe the ambient electromagnetic environment. "There should be a vigorous definition of the environment," stressed Don Briggs of General Motors, who represented the Motor Vehicle Manufacturers Association's electromagnetic compatibility committee.

Crawford, of NBS, said he will pick a time for the first meeting of the umbrella group after corresponding with group members.

McGehan is a public information specialist with the NBS Boulder Program Information Office.

*See DIMENSIONS/NBS March 1978 for a discussion of EMI.

STAFF REPORTS

NEW GAS FLOW MEASUREMENT METHOD USES CRYOGENIC TECHNIQUES

Direct comparison of ambient temperature gas flow measurements to a mass flow standard is made possible by a new continuous closed-loop measurement method.

The complete gas flow reference system has not been demonstrated physically; however, the liquefied gas portion has been proven over a period of six years and is the flow standard for the recently developed cryogenic flowmeter code. Modifications are state-of-the-art additions of heat exchangers and process control. It is believed that the accuracy of the liquid system (less than ±0.2 percent) will be maintained after modification.

D. B. Mann, Thermal Physical Properties Division, 2-1001, Boulder, Colo. 80303, 303/499-1000, ext. 3652 and J. A. Brennan, Thermal Physical Properties Division, 2-1008, Boulder, Colo., 80303, 303/499-1000, ext. 3611.

A new and more accurate method of measuring gas flow in terms of mass is possible using existing, well developed cryogenic techniques. The method, which could be used to redefine present gas flow measurement codes and standards, is a natural and logical development from codes and standards measurements of cryogenic liquids such as oxygen, nitrogen, and argon. The method is closed-looped allowing extended periods of observations at set gas pressures, temperatures, and flow rates. Gas pressures up to 6.9 MPa (1000 psi) and gas temperatures above ambient temperatures are possible. The method is suitable for air, oxygen, nitrogen, argon, methane, and natural gas mixtures of methane, ethane, propane, butane, and nitrogen, and could be extended to neon, hydrogen, helium, and other fluids.

Total uncertainty in mass flow is based on an existing cryogenic flow reference facility with over six years of operational experience. Upon completion of modifications to accommodate gas flow measurements, we project gas flow measurements and standards could be improved by a factor of from five to ten.

Other studies possible with this new method are a) direct comparison of gas to liquid flow on a mass basis, b) intercomparison of gas to water or other fluid flow on a mass basis, c) performance of gas flowmeters operating on low temperature gases, and d) investigation of Reynolds number variations at constant mass flow.

In February of 1977, a paper "On a New Method of Gas Flow Measurement Using Cryogenic Techniques" describing this new process for measurement of gas flow was presented at the Symposium on Flow in Open Channels and Closed Conduits held at NBS, Gaithersburg, Md. The paper described the general approach and suggested a two step implementation.

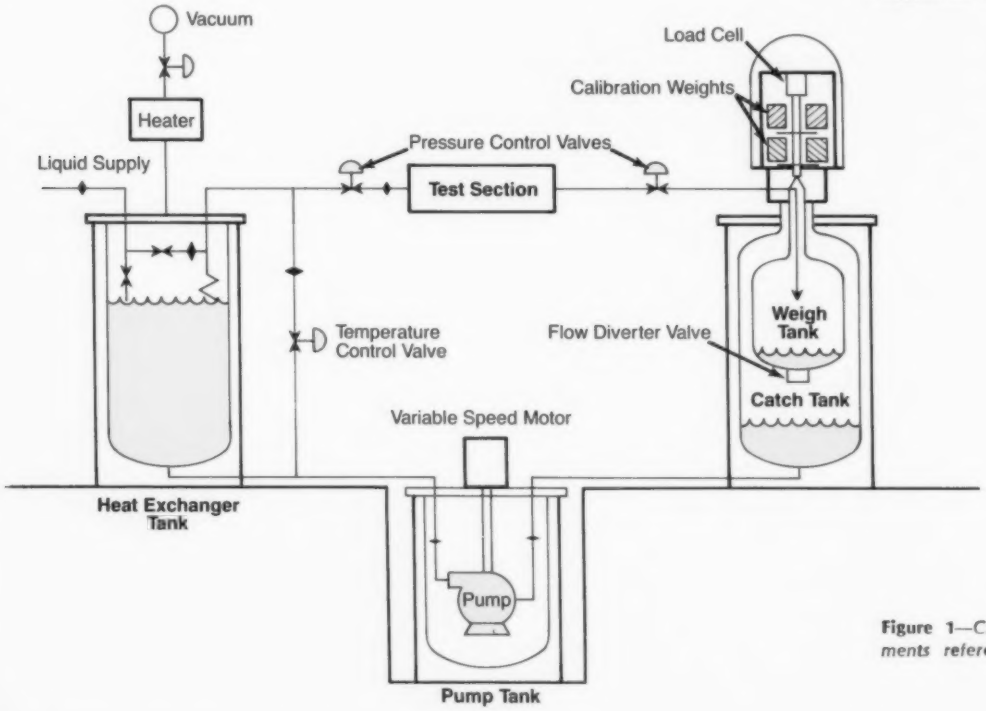


Figure 1—*Cryogenic flow measurements reference facility schematic.*

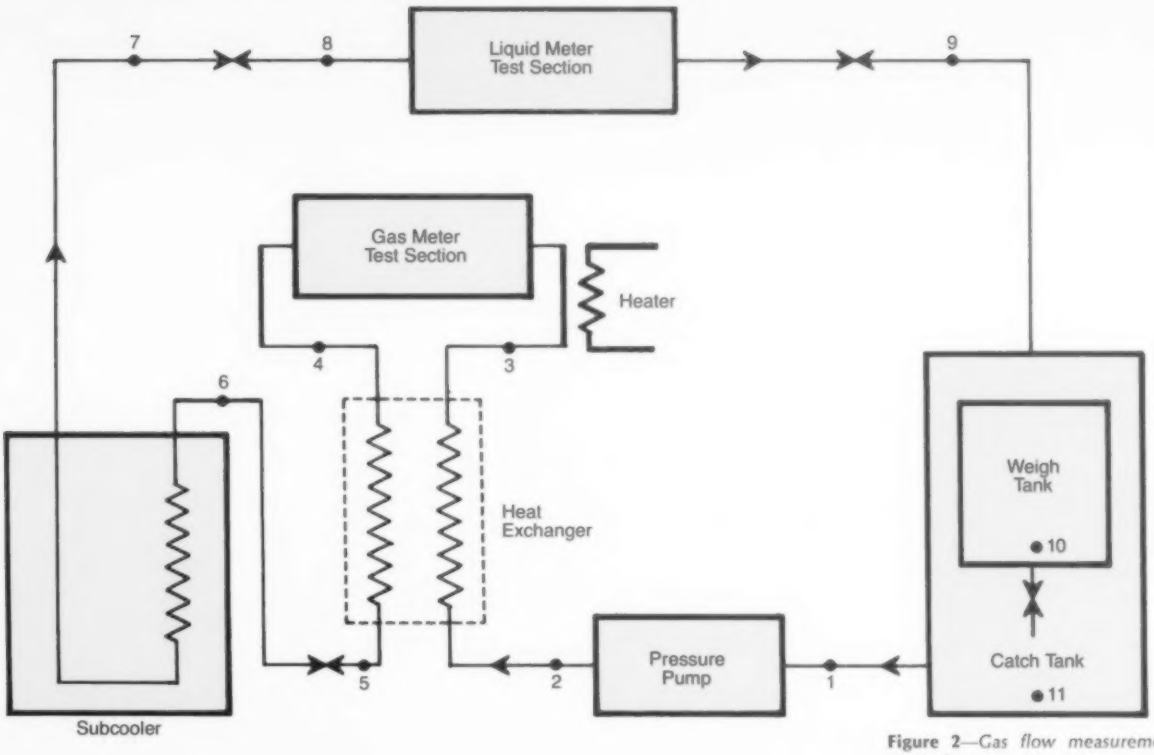


Figure 2—*Gas flow measurement system schematic for operation at greater than critical pressures.*

The first of these two steps is to modify the existing cryogenic flow reference system and provide adequate proof that the significant improvements in the accuracy and precision do exist (prototype). The second step is the design, construction, and operation of a facility of such capacity as to be useful for larger line sizes.

System Modification

The existing cryogenic flow reference system of figure 1 is modified in the prototype gas flow reference system as shown in figure 2. A pressure pump and bypass valve are substituted for the circulation pump and a heat exchanger, gas temperature trim heater, gas meter test section, and expansion valve are added to the system as new equipment.

The new cycle can further be understood by referring to figure 3, which shows a temperature entropy plot of the cyclic process. Starting at point 1, liquid is compressed in the pressure pump to a pressure greater than the critical pressure of nitrogen, 3.40 MPa (493 psi). The liquid is then introduced into the two pass counter flow heat exchanger and is warmed to near ambient temperature at point 3. The temperature of the gas is controlled by means of the trim heater and passes into the gas meter test section, at point 8 returning to the heat exchanger at point 4. The gas is then cooled in the heat exchanger to point 5 where it is expanded to the cryogenic mass flow measurement section at an absolute pressure of approximately 0.69 MPa (100 psi) at point 6. The fluid (nitrogen) is then subcooled to remove thermal effects of heat exchanger inefficiency and pump work and passes through an optional liquid meter test section at point 8 and then to the mass flow measurement weigh and catch tank system at point 11.Cryogenic side pressures are maintained using helium gas pressurization.

Mass flow stability throughout the cyclic process is essential to establishing the accuracy and precision of the gas flow measurement. Thus a minicomputer is being adapted for process control and data access.

System Improvements

The ability of the existing cryogenic flow reference system to make a mass measurement has been described in detail by J. W. Dean, et. al., (1971).*

This report is a summary of an 18-month study to determine the accuracy of the flow reference system. "At this time, the uncertainty of the measurement of totalized mass flow is estimated to be ± .18 percent. This figure includes an uncertainty of ± 0.12 percent for known sources of systematic errors plus an uncertainty of ± 0.06 percent for random error. The estimated uncertainty due to the random error is three times the standard deviation calculated from 23 applications of the calibrated masses over a period of three months."

Since publication of this uncertainty statement, the system has been kept under statistical control by maintaining a chronological control chart of load cell sensitivity and the incorporation of variable test drafts into all experimental test plans. With these controls, it is possible to establish with confidence that the system is operating within the estimated errors originally calculated.

Applications

Direct comparison of ambient temperature gas flow measurements to a mass flow standard will be possible by the new continuous closed loop measurement method. The anticipated total uncertainty in mass flow of gas at operating conditions should not exceed ± 0.2 percent. This is an improvement of a factor of 5 to 10 over existing gas flow standards.

If the total system uncertainty can be maintained at ± 0.2 percent or less, the potential is impressive and would allow the following studies:

turn page

* J. W. Dean, J. A. Brennan, D. B. Mann, and C. H. Kneebone, Cryogenic Flow Research Facility Provisional Accuracy Statement, Nat. Bur. Stand. (U.S.), Tech. Note 606, (July 1971).

• Redefinition of gas flowmeter factors relative to mass flow directly and continuously. No intermediate calculations or approximations are required.

• Gas flow pressures and temperatures could be controlled independently of the mass flow reference and would allow wide variations in experimental conditions. An added benefit, particularly in the case of nitrogen as the process fluid would be that the Reynolds number can be increased by a factor of 4 or 5 by reducing the temperature and therefore the viscosity of the gas.

• Gas flowmeter performance could be compared directly with existing codes and standards which are based on volumetric or water calibration predictive calculations. Errors in predictive correlations could be identified and corrected.

• The working hypothesis that water calibration may be transferred directly to gas flow can be tested to an accuracy not previously possible. Errors in this hypothesis can be identified and corrected.

• The effects of upstream and downstream meter flow conditioning (straight runs and/or flow straighteners) can be redefined with gas flow with greater accuracy than previously available.

• Evaluations of potential gas flow transfer standards on a long term mass flow basis. This would include such device as the choked nozzle and new devices such as the laser Doppler velocimeter or ultrasonic meters, the success of which would make gas flow or water flow reference systems increasingly unnecessary.

• An evaluation of velocity effects on direct reading densitometers. This work would be in support of the development of a natural gas energy meter.

• As a precision reference system, test sections could be used to investigate the development of boundary layers and turbulence, and the effects of these phenomena on gas meter size.

It is anticipated that by late 1978 the majority of the modifications to the existing flow reference system will be completed and we may then begin debugging the system.

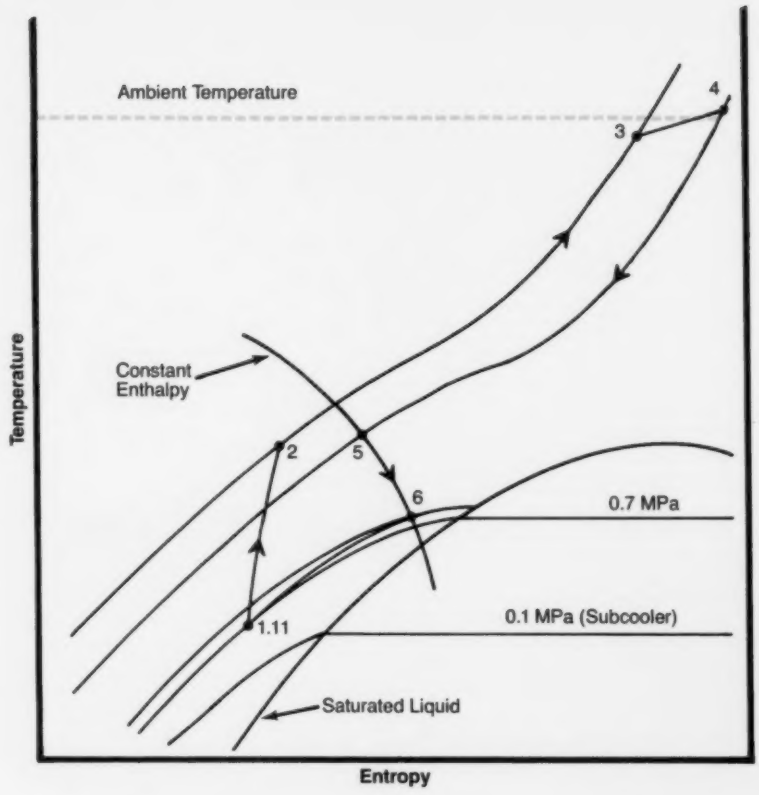


Figure 3—*Operation of flow measurements system at above critical pressures (indicated pressures are absolute).*

RESEARCH BEGUN ON POLICE RADAR AND OTHER SPEED MEASURING EQUIPMENT

The National Bureau of Standards has begun a project to test police radar and other speed-measuring equipment used in law enforcement.

Marshall Treado, Law Enforcement Standards Laboratory, B150 Physics Building, 301/921-3161.

The primary objective of a new NBS program is to develop performance standards for various speed measuring devices and to establish qualified products lists of devices that meet these standards. Law enforcement agencies that purchase these devices using federal highway safety funds will be required to select from the lists.

More than 7000 speed measuring devices were purchased between 1968 and 1973 by police agencies aided by some $6 million in federal funds. Since then, enforcement of the 55 mph (88 km/h) national speed law has significantly increased the number of speed measuring devices being purchased.

The three-year project, which is sponsored by the National Highway Traffic Safety Administration (NHTSA) of the U.S. Department of Transportation, will be carried out by the NBS Law Enforcement Standards Laboratory.

Tests will be conducted on mobile and stationary radar, other electronic speed measuring devices, speedometers, and odometers. Performance standards will be developed for all types of speed-measuring equipment commonly used in law enforcement. These standards will then be used to test various models. Those that meet the requirements of the standards will be placed on qualified products lists to be published in the *Federal Register* by the NHTSA. Finally, a compliance information system will be established to obtain feedback on the performance of this equipment while in actual use.

STRAIN TIDE SPECTROSCOPY

Data from the 30-meter laser strainmeter in the Poorman Mine west of Boulder, Colorado, have yielded the theoretically predicted, nearly daily resonance of the earth resulting from the interaction of the mantle and the liquid core. With a frequency close to one cycle per sidereal day and a spectral line width less than one cycle per year, the resonance was detected by calculating the transfer function between the applied gravitational potential and the observed strain.

Judah Levine, Time and Frequency Division, A503 (Joint Institute for Laboratory Astrophysics), Boulder, Colo., 80303, 303/499-1000, ext. 3903.

In this paper we present an analysis of almost 3 years of strain tide data. The work was motivated in part by calculations suggesting that significant anomalies might exist in the response of the earth to tidal excitations near one and two cycles/day.

An anomaly in the earth tidal response to excitations near one cycle/sidereal day arises from the near degeneracy between the tidal frequencies and a free nutation mode of the earth. The mode results from the interaction of the liquid core with an elliptical, rotating mantle, and its effects on the earth tides can be modeled as a strong frequency dependence of the effective Love numbers for the various diurnal components.

The interest in high-precision experiments to test gravitational theories has given rise to a theoretical framework to systematize the comparison between theory and experiment. This framework has taken the form of the parameterized post-Newtonian PPN formalism (Will, Nordtvedt 1972). This formalism has been used to search for new tests of general relativity and to examine the viability of various theories that have been proposed as alternates to the general theory.

Some theories of gravity single out a "preferred" frame related to the mean rest-frame of the Universe. These theories have recently been shown to predict observable effects related to the velocity of the solar system relative to this frame. In particular, the sidereal rotation of the earth at frequency Ω about its axis and its orbital sidereal motion at frequency ω will produce anomalous tides at these frequencies, their harmonics, and their sums and differences.

In the present work, we compare the spectrum of earth strain tide data with the spectrum of the theoretical response of the earth. We obtained our data using the laser strainmeter in the Poorman mine over a period of about 980 days starting on May 21, 1974. The heart of the strainmeter is an evacuated 30-meter Fabry-Perot interferometer located along an axis 7° west of north.

The tidal anomalies that we are studying produce anomalous amplitudes at certain classical tidal frequencies. It is therefore not sufficient to characterize a certain tidal theory in terms of its predictive power for the total time series or even in terms of the root mean square deviation of the calculated series from the "true" tides. We must be concerned with the spectrum of the deviations to be sure that large errors do not exist in the calculation of small components, and that the spectrum of the deviations is relatively flat.

We have used two independent methods for calculating the astronomical input for the earth tide calculations. Our primary calculations were done using the results of Cartwright and Taylor (1971) and Cartwright and Edden (1973). These amplitudes were checked by a direct calculation using the Jet Propulsion Laboratory ephemeris DE-96 (Newhall 1976).

We have used in our analysis all of the diurnal and semidiurnal components published by Cartwright and Edden. For each component we construct a time series of the form:

$$a_\kappa \cos (2\pi f_\kappa t + \Phi_\kappa + \alpha_\kappa)$$

where a_κ is the amplitude given by Cartwright and Edden, f_κ is the frequency (in cycles/hour). Φ_κ is the phase (in degrees) at the start of the analysis epoch, t_o, and α_κ is $-90°$ if the term arises from a spherical harmonic Y_n^m in which $(n+m)$ is odd and is zero otherwise. Each term is then multiplied by the appropriate spherical harmonic of the station co-latitude θ and east longitude ϕ, and by an algebraic function of the station coordinates and the strainmeter orientation θ_s (measured clockwise from north):

$$a_\kappa \cos (2\pi f_\kappa t + \Phi_\kappa + \alpha_\kappa)\ Y_n^m (0, \phi)\ T (n, m, \theta, \phi, \theta_s)$$

where Y_n^m is the normalized spherical harmonic and T is a function converting the applied gravitational potential to the observed earth strain. The theoretical series were further modified by a function to correct for local topography, local crustal inhomogeneities, cavity effects and ocean loads. We assumed initially that these effects do not vary rapidly with frequency, that all of the diurnal components have the same correction as the dominant diurnal terms, O_1, and that all of the semidiurnal components have the same correction as the dominant semidiurnal term, M_2. These corrections appear as amplitude corrections and phase shifts.

In addition to these time series, we included a time series of barometric pressure readings obtained at the mine. These series were fit to the data with amplitudes and phases that were adjusted for a best fit in at least squares sense. To do this, we multiply each of the series computed above by an adjustable complex parameter. The magnitudes and phases of these parameters are simultaneously adjusted to minimize the differences between the fitting functions and the data. The values of these parameters give our best estimate of the ratio between the observed amplitude at a given frequency and the theoretically expected amplitude, and are termed the transfer functions. The transfer function amplitude for the diurnal tidal band is plotted in figure 1 and the phase is plotted in figure 2. The corresponding quantities for the semidiurnal band are plotted in figure 3.

The error bars represent one standard deviation and are obtained from estimates of the noise. They do not include any possible systematic effects.

turn page

Discussion of Results

The amplitude of the diurnal transfer function shows statistically significant structure. There appears to be a significant decrease in the transfer function for the low frequency diurnal components. We attribute this to a slow change in the contribution of the ocean load to our observed data.

More significantly there is a dip in the transfer function near one cycle/day (we have not plotted the S_1 amplitude at one cycle/day since it is heavily contaminated by thermo-elastic processes). This dip is consistent with the effects of the nearly-diurnal resonance associated with the liquid core. The consistency can be shown more clearly by inserting the resonance directly into the fitting function by using the frequency dependent Love numbers published by Molodensky and by Shen and Mansinha (1976). These Love numbers produce changes in the transfer function at all of the diurnal frequencies but, except near one cycle/day, the new transfer function lies within the one standard deviation error bars of the old one. The modified transfer function is shown in figure 4. As can be seen from the figure the resonance models account for the dip in the transfer function near one cycle/day.

The semidiurnal transfer function amplitude shows far less structure, and the agreement between experiment and theory is good (i.e. the transfer function magnitude is close to unity). There is no evidence of anomaly at S_2 (two cycles/day) confirming that the anomaly at S_1 is almost certainly of thermoelastic origin. There is no evidence of an anomaly at R_2, the component which would be affected by the existence of a preferred frame effect.

We may place upper limits on the various PPN parameters by calculating the magnitudes of the anomalous tidal components in terms of the PPN parameters α_2 and C_W. These anomalous effects appear as additional terms in the applied potentials, so that we may use the machinery we have already developed for calculating the strain.

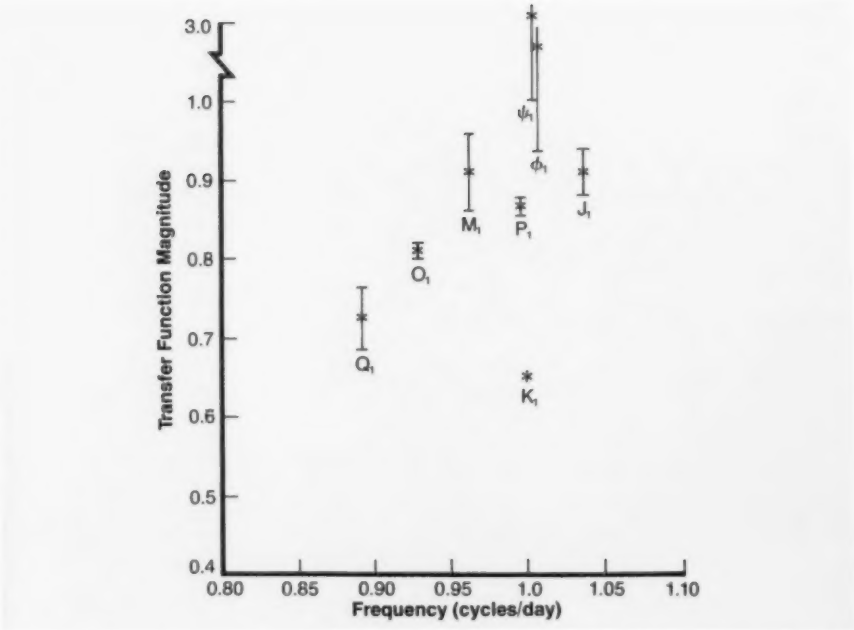


Figure 1—*Normalized transfer function amplitude for the diurnal tides. For clarity only the major components are plotted. The error bars are one standard deviation.*

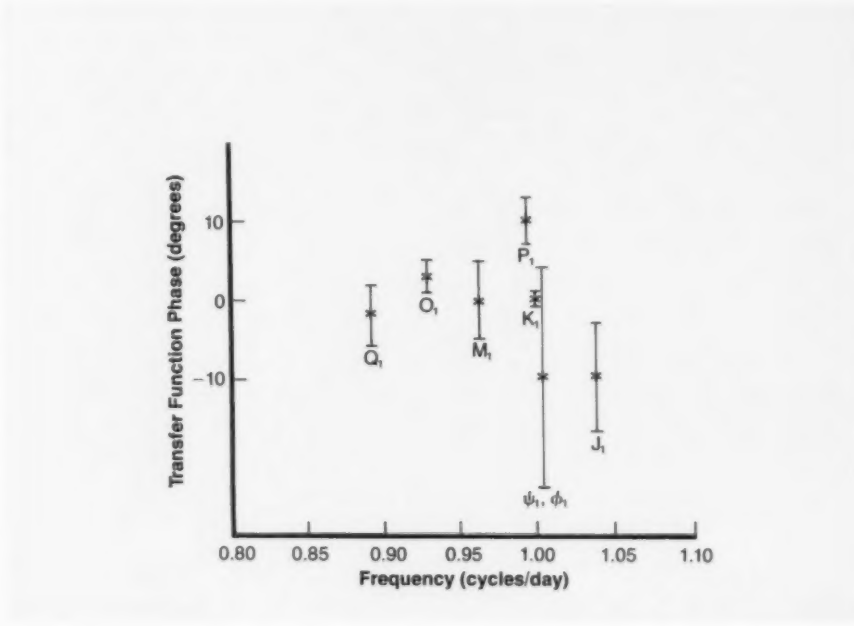


Figure 2—*Normalized transfer function phase for the diurnal tides. For clarity only the major components are plotted. The error bars are one standard deviation.*

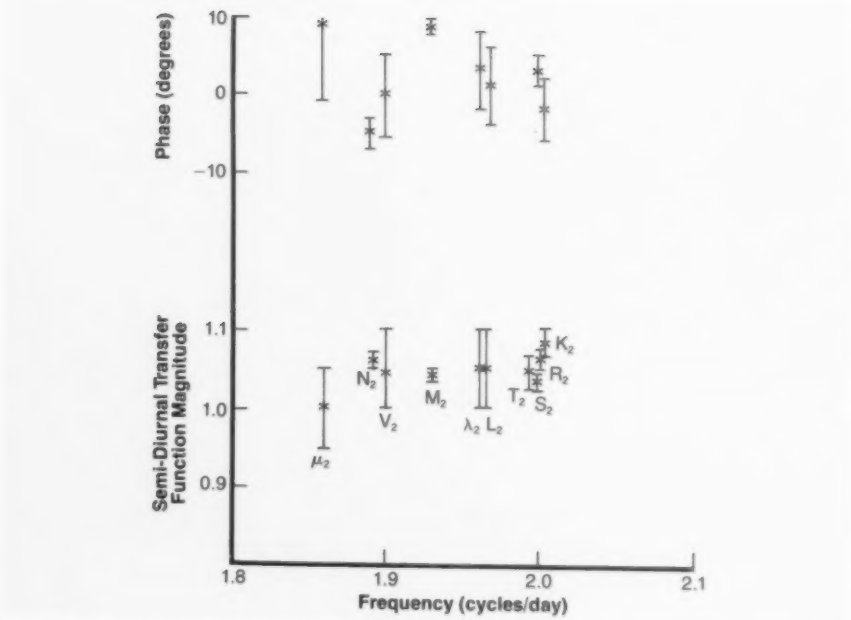


Figure 3—*Normalized transfer function amplitude (lower curve) and phase (upper curve) for the semidiurnal tides. For clarity only the major components are plotted. The error bars are one standard deviation.*

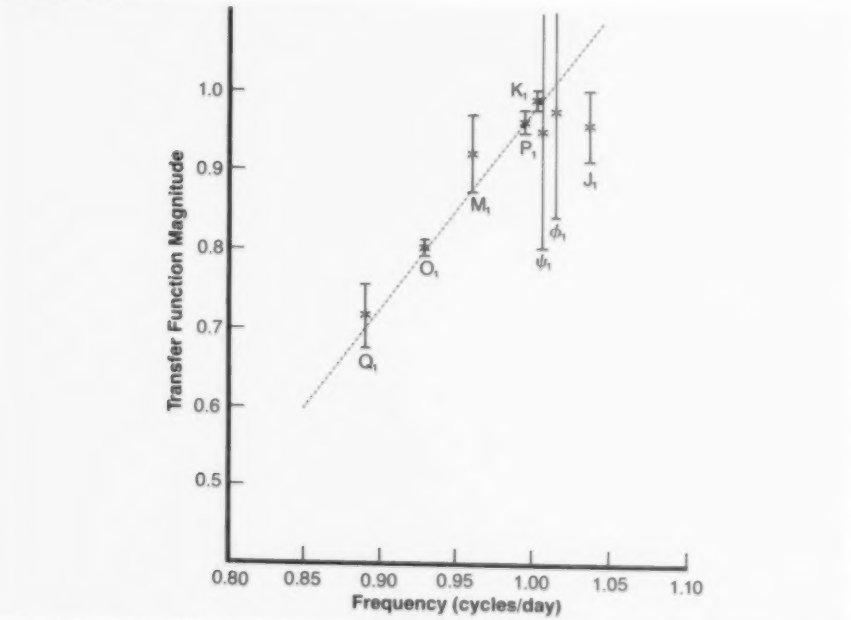


Figure 4—*Normalized transfer function amplitude for the diurnal tides when the frequency dependent Love numbers are inserted into the fitting function. The dashed line is obtained by fitting a straight line to the transfer function amplitudes weighted by their respective uncertainties.*

The measured strain is related to the applied potential by the quantities T $(n,m,\theta,\phi,\theta_s)$. The value of T at our station (θ=49.97°, ϕ=254.67°) is approximately 0.17 for diurnal tides and 0.35 for semidiurnal tides. The response of a gravity meter is approximately 1.18 times the applied potential in the same units so that the strainmeter provides a weaker test of these effects.

We feel that our measurements of the transfer function near one and two cycles/days are consistent with the hypothesis that the ocean load is a smoothly varying function of frequency over the narrow range of frequencies near one and two cycles/day. With this assumption the most sensitive test for a nonzero value of the PPN parameter α_2 comes from an examination of K_1 (the component with the largest anomalous tide) relative to O_1 and P_1. We conclude that the anomalous strain amplitude at K_1 does not exceed 1.5×10^{-11}. The anomalous tide has an amplitude of approximately $210 \times 10^{-10}\ \alpha_2$ so that $\alpha_2 \leq 0.007$.

We estimate an upper bound to to the anisotropy parameter c_w in the same way. The amplitude of the anomalous tide at one cycle/sidereal day is $3 \times 10^{-8}\ c_w$ while the amplitude at two cycles/sidereal day is $2.5 \times 10^{-8}\ c_w$. Thus the diurnal test yields $c_w \leq 0.005$ while the semidiurnal test yields a somewhat larger upper bound ($c_w \leq 0.007$).

Cartwright, D.E. and Edden, A.C., 1973. Corrected tables of tidal harmonics. Geophys. J. Roy, Astron. Soc., 33, 253-264.

Cartwright, D.E. and Tayler, R.J., 1971. New computations of the tide-generating potential, Geophys. J. Roy, Astron. Soc., 23, 45-74.

Newhall, S., 1976. JPL Export Ephemeris, DE-96, Jet Propulsion Laboratory, Pasadena, California.

Nordtvedt, K. Jr., and Will, C.M., 1972. Conservation laws and preferred-frames in relativistic gravity. II. Experimental evidence to rule out preferred frame theories of gravity, Astrophys. J., 177, 775-792.

Shen, Po-Yu and Mansinha, L., 1976. Oscillation, nutation, and wobble of an elliptical rotating earth with liquid outer core. Geophys. J. Roy, Astron. Soc., 46, 467-496.

Will, C. M. and Nordtvedt, K. Jr., 1972. Conservation laws and preferred frames in relativistic gravity. I. Preferred-frame theories and an extended PPN formalism. Astrophys. J., 177, 757-774.

CONFERENCES

For general information on NBS conferences, contact Sara Torrence, NBS Public Information Division, Washington, D.C. 20234, 301/921-2721.

TWO SYMPOSIA ON ULTRASONIC CHARACTERIZATION

Two international conferences on ultrasound characterization will take place next month at National Bureau of Standards headquarters in Gaithersburg, Md.

The Third International Symposium on Ultrasonic Imaging and Tissue Characterization will be held June 5-7. Cosponsored by NBS and the National Institutes of Health, the symposium will focus on the state-of-the-art, new directions of technology, and research opportunities in the noninvasive characterization of the ultrasonic properties of tissue. The meeting will serve to promote the transfer of new technological advances in medical ultrasound to clinical application.

The First International Symposium on Ultrasonic Materials Characterization will be held June 7-9. It is the first meeting exclusively devoted to fundamental measurement methods that offer potential for the practical assessment of material performance. This meeting will overlap with the Ultrasonic Imaging and Tissue Characterization Symposium to give participants an opportunity to discuss common problems and compare progress in medical and industrial ultrasonics.

Sessions at the Third International Symposium on Ultrasonic Imaging and Tissue Characterization will be devoted to:

—techniques for measurement of ultrasonic parameters (velocity, attenuation, absorption, scattering, impedance);
—imaging techniques, including transducer and array technology;
—computerized tomography;
—signal processing and pattern recognition;
—Doppler techniques;
—microscopy;
—ultrasonic parameters of tissue and their dependence on physical and biological variables (e.g. ultrasonic frequency, temperature); and
—standards and calibration methods.

The First International Symposium on Ultrasonic Materials Characterization will consider topics such as:

—ultrasonic methods for determination and verification of material properties (stress, hardness, grain and bonding, for example) by measurements such as velocity, attenuation, absorption and scattering;
—ultrasonic characterization of defects in terms of type, size, shape, orientation and location; and
—new ultrasonic instrumentation, transducer developments and approaches to standards for calibration.

For further information, contact: Dr. Melvin Linzer, A329 Materials Building, 301/921-2858 (Ultrasonic Imaging and Tissue Characterization) and Harold Berger, A363 Materials Building, 301/921-3331 (Ultrasonic Materials Characterization).

TODAY'S, TOMORROW'S MICROCOMPUTERS SYMPOSIUM

Current and future benefits of microcomputer technology wil be weighed at a Symposium on Microcomputer-Based Instrumentation, to be held at the National Bureau of Standards, Gaithersburg, MD, on June 12-13, 1978.

Sessions in four major areas, each highlighted by an overview presentation, will focus, respectively, on microcomputer interface standards, and applications to industrial process control.

This symposium, cosponsored by NBS, the Institute of Electrical and Electronics Engineers (IEEE) Computer Society, and the IEEE Group on Instrumentation and Measurement, will mark the opening of a series on Challenges in Science and Technology.

The symposium series, instituted by NBS Director Dr. Ernest Ambler, is intended to encourage a cross-fertilization of ideas from many disciplines. Participating scientists of diverse backgrounds will jointly assess current trends and future needs. Each symposium will feature contributed or invited papers from within and outside the Bureau.

Major papers at the June 12-13 symposium will include:

- Microcomputers for Biomedical and Clinical Applications
- Microprocessor-Based Satellite Controlled Clock
- Fault Tolerance in Distributed Architectures
- Microcomputers in the Linear World
- Control of a 1 Gigahertz CCD Transient Digitizer
- Automating Analytical Instrumentation

For more information on sessions or schedules for the microcomputer symposium, contact Bradford M. Smith, A130 Technology Building, National Bureau of Standards, Washington, D.C. 20234; phone 301/921-2381.

The second event in the series will be the Symposium on Atomic and Molecular Science and Technology, September 7-8, 1978.

For details, contact Dr. Stephen J. Smith, Joint Institute for Laboratory Astrophysics (JILA), National Bureau of Standards, Boulder, Colorado 80303; phone 303/499-1000, extension 3631.

Tentatively scheduled for January 1979 is the third in the series, a Symposium on Mathematical Modeling. For details, contact Dr. J. R. Rosenblatt, NBS Applied Mathematics Division, A337 Administration Building, Washington, D.C. 20234; phone 301/921-2315.

CONTROLLED RELEASE OF BIOACTIVE MATERIALS SYMPOSIUM

From algicides and antifoulants to nutrients and pharmaceuticals, the 5th International Symposium on Controlled Release of Bioactive Materials will deal with broadened applications and problems in this new and changing field. The symposium will be held at the National Bureau of Standards, Gaithersburg, Md., August 14-16, 1978.

Questions of environmental impact, government regulation, and relative effec-

tiveness of various new chemicals confront the pesticide, nutrient, and pharmaceutical industries. The symposium will emphasize controlled release technology and materials, mode of action, and measurement of service life or environmental impact. Plenary sessions will cover:

- Controlled Release Theory and Modeling
- Measurement for Environmental Assessment
- New Formulation Technology
- Hazard Evaluation for Manufacturers and Users

Papers to be presented at the symposium will explore terrestrial and aquatic pesticides, attractants and repellents, fertilizers, pharmaceutical chemistry, measurement needs, nutrients, and other areas.

For further information contact: Dr. Frederick E. Brinckman, A325 Materials Building, 301/921-2847.

CONFERENCE CALENDAR

June 12-13
MICROCOMPUTER BASED INSTRUMENTATION CONFERENCE, NBS, Gaithersburg, MD; sponsored by NBS, IEEE Computer Society, IEEE Group on Instrumentation and Measurement; contact: Bradford Smith, A130 Technology Building, 301/921-2381.

June 15
TOOLS FOR IMPROVED COMPUTING IN THE 80's, NBS, Gaithersburg, MD; sponsored by NBS and the Washington, D.C. Chapter of the Association for Computing Machinery; contact: Trotter Hardy, A367 Technology Building, 301/921-3491.

June 19-21
GAS KINETICS CONFERENCE, NBS, Gaithersburg, MD; sponsored by NBS and the Committee on Chemical Kinetics, NBS, Committee on Chemical Kinetics of the National Academy of Sciences/National Research Council; contact: David Garvin, B154 Chemistry Building, 301/921-2771.

June 26-29
CONFERENCE ON PRECISION ELECTROMAGNETIC MEASUREMENTS, Ottawa, Ontario, Canada; sponsored by Institute of Electrical and Electronics Engineers, U.S. National Committee-International Union of Radio Science, and NBS; contact: Dee Belsher, NBS, Boulder, Colo., 303/499-1000, ext. 3981.

July 13
WORKSHOP ON SUMMER ATTIC VENTILATION AND WHOLE HOUSE FAN VENTILATION, NBS, Gaithersburg, MD; sponsored by NBS; contact: Douglas M. Burch, B122 Building Research Building, 301/921-3513.

July 17-20
FOURTH ANNUAL CONFERENCE OF THE AMERICAN ASSOCIATION FOR CRYSTAL GROWTH, NBS, Gaithersburg, MD; sponsored by NBS and AACG; Robert L. Parker, B164 Materials Building, 301/921-2961.

August 14-16
5TH INTERNATIONAL SYMPOSIUM ON CONTROLLED RELEASE OF BIOACTIVE MATERIALS, NBS, Gaithersburg, MD; sponsored by NBS; contact: Frederick Brinckman, A325 Materials Building, 301/921-2847.

*September 7-8
SYMPOSIUM ON ATOMIC AND MOLECULAR SCIENCE AND TECHNOLOGY, NBS, Gaithersburg, MD; sponsored by NBS; contact: Stephen Smith, NBS, Boulder, Colo., 303/499-1000, ext. 3631.

*New Listings

September 18-22
CHARACTERIZATION OF HIGH-TEMPERATURE GASES, NBS, Gaithersburg, MD; sponsored by NBS, contact: J. Hastie, A307 Materials Building, 301/921-2859.

October 4-6
NATIONAL CONFERENCE OF STANDARDS LABORATORIES, NBS, Gaithersburg, MD; sponsored by NBS and the National Conference of Standards Laboratories; contact: Brian Belanger, A345 Physics Building, 301/921-2805.

*October 10-12
3RD ANNUAL CONFERENCE ON MATERIALS FOR COAL CONVERSION AND UTILIZATION, NBS, Gaithersburg, MD; sponsored by NBS and DoE, contact: Samuel Schneider, B308 Materials Building, 301/921-2894.

November 13-15
CERAMIC MACHINING AND SURFACE FINISHING II, NBS, Gaithersburg, MD; sponsored by NBS, Office of Naval Research, Air Force Office of Scientific Research, and the American Ceramic Society; contact: Bernard Hockey, A345 Materials Building, 301/921-2901.

*November 28-30
MECHANICAL FAILURES PREVENTION GROUP, San Antonio, Texas; sponsored by NBS and MFPG; contact: Harry Burnett, B264 Materials Building, 301/921-2813.

PUBLICATIONS

TEACHER AIDS

The following materials produced by agencies of the federal government have been examined and recommended by DIMENSIONS/NBS for their potential value as supplements to the classroom or school library.

Famous Boundary of Creation

A 28-minute, 16 mm sound/color film available on free loan from the National Oceanic and Atmospheric Administration (NOAA). The film deals with the dynamics of the earth's crust as illuminated by French-American studies of the mid-Atlantic ridge. Distinguished by beautiful underwater photography around Iceland, Hawaii, and the Azores, the film was produced in cooperation with the National Science Foundation and Woods Hole Oceanographic Institutions. For free loan (no charge except for return postage), contact: Motion Picture Service, Department of Commerce-NOAA, 12231 Wilkins Avenue, Rockville, MD, 20852. Phone: 301/443-8411.

Early Stationary Steam Engines in America: A Study in the Migration of a Technology

This 152-page hardback by Carroll W. Pursell, Jr., is a Smithsonian Institution Press study now available at half-price. Replete with vintage drawings and engravings from colonial times through the nineteenth century, the book redresses the balance by focusing on the "less spectacular subject of stationary engines," heretofore eclipsed by "the drama and glamour of steamboats and railroads. . . ." Order at $4.50 (half-price) from: Smithsonian Institution Press, P.O. Box 1641, Washington, D.C. 20013.

WIND STUDY

Building to Resist the Effect of Wind. Volume 1: Overview, Marshall, R. D., Raufaste, N. J., Jr., Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 100-1, 34 pages (May 1977) Stock No. 003-003-01717-5, $1.40.

Building to Resist the Effect of Wind. Volume 2: Estimation of Extreme Wind Speeds and Guide to the Determination of Wind Forces. Simiu, E., Marshall, R. D., Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 100-2, 29 pages (May 1977) Stock No. 003-003-01718-3, $1.30.

Building to Resist the Effect of Wind. Volume 3: A Guide for Improved Masonry and Timber Connections in Buildings, Fattal, S. G., Sherwood, G. E., and Wilkinson, T. L., Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 100-3, 56 pages (May 1977) Stock No. 003-003-01719-1, $2.

Building to Resist the Effect of Wind. Volume 4: Forecasting the Economics of Housing Needs: A Methodological Guide. Kowalski, J. G., Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 100-4, 36 pages (May 1977) Stock No. 003-003-01720-5, $1.50.

Building to Resist the Effect of Wind. Volume 5: Housing in Extreme Winds: Socio-economic and Architectural Considerations. Kliment, S. A., AIA, Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 100-5, 37 pages (May 1977) Stock No. 003-003-01721-3, $1.50.

The National Bureau of Standards' Center for Building Technology has published a five-volume series to assist Asian and Caribbean wind-prone countries in improving design criteria for low-rise buildings (less than 10 meters high) to better resist extreme winds.

The series, "Building to Resist the Effect of Wind," designated Building Science Series 100-1 through 5, is the result of a 3½ year research project sponsored by the Agency for International Development. The project was designed to reduce loss of life and property damage when the design criteria are applied properly. The three countries participating in the study were the Philippines, Jamaica, and Bangladesh.

One measure of the problem is the fact that the Philippines experienced four typhoons in 1970, causing 1,000 deaths and $45 million in property damage. Some 300,000 school children were displaced when 9,000 public school classrooms were destroyed.

METHODS TO REDUCE PROGRESSIVE COLLAPSE IN BUILDINGS

Design Methods for Reducing the Risk of Progressive Collapse in Buildings, Leyendecker, E. V., and Ellingwood, B. R., Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 98, 68 pages (Apr. 1977) Stock No. 003-003-01765-5, $1.30.

Information on how to design structures so that they will be resistant to chain reactions of failures after a small portion of a building has been damaged is contained in a National Bureau of Standards publication, *Design Methods for Reducing the Risk of Progressive Collapse in Buildings.*

The report, which should be useful to architects, construction engineers, and safety and code authorities, presents two major design approaches which can be applied to all types of structures. They are:

The alternate path method which deals with the need for a structure to "bridge over" a building's damaged portion, that is, to absorb the effects of a localized structural failure and so avoid its spread through the rest of a building; and the specific local resistance method which supplies criteria to design structural elements with enough strength to prevent a local failure.

The set of procedures in the study by Edgar V. Leyendecker and Bruce R. Ellingwood of the NBS Center for Building Technology includes equations for load combinations and appropriate load factors. Also included is a discussion of concepts associated with progressive collapse and abnormal loading events.

This type of structural failure, the report notes, has been identified as a serious enough problem to warrant consideration in design. Mounting evidence suggests that although certain new and economical multistory structural forms may comply with established codes, they may not resist progressive collapse as well as older framed buildings. The report states in its conclusion that even though the normal design process results in a certain amount of strength and continuity which is also available to resist progressive collapse, such protection may vanish in the future because "codes, standards, and building materials, as well as construction techniques, change with time."

Besides aiding designers now, the design methods also lay the groundwork for developing standards for buildings to achieve progressive collapse resistance.

Atomic and Molecular Studies

Meggers, W. F., and Tech, J. L., The First Spectrum of Ytterbium (Ybi), J. Res. Nat. Bur. Stand. (U.S.), 83 No. 1, 13-70 (Jan.-Feb. 1978).

Computer Science and Technology

Lyon, G., Computer Science and Technology: COBOL Instrumentation and Debugging: A Case Study, Nat. Bur. Stand. (U.S.), Spec. Publ. 500-26, 33 pages (Jan. 1978) Stock No. 003-003-01873-2, $1.40.

Ruder, B., Madden, J. D., and Blanc, R. P., Ed., Computer Science and Technology: An Analysis of Computer Security Safeguards for Detecting and Preventing Intentional Computer Misuse, Nat. Bur. Stand. (U.S.), Spec. Publ. 500-25, 80 pages (Dec. 1977) Stock No. 003-003-01871-6, $2.40.

Health and Safety

Juhasz, A. A., The Reduction of Airborne Lead in Indoor Firing Ranges by Using Modified Ammunition, Nat. Bur. Stand. (U.S.), Spec. Publ. 480-26, 27 pages (Nov. 1977) Stock No. 003-003-01821-0, $1.20.

Meguire, P. G., Kramer, J. J., and Stewart, A., Security Lighting for Nuclear Weapons Storage Sites: A Literature Review and Bibliography, Nat. Bur. Stand. (U.S.), Spec. Publ. 480-27, 38 pages (Nov. 1977) Stock No. 003-003-01838-4, $1.50.

Electromagnetic Metrology

Yaghjian, A. D., Near-Field Antenna Measurements on a Cylindrical Surface: A Source Scattering-Matrix Formulation, Nat. Bur. Stand. (U.S.), Tech. Note 696, (Rev. Sept. 1977), 40 pages (Sept. 1977) Stock No. 003-003-01850-3, $1.50.

Energy Conservation and Production

Mangum, B. W., and Hill, J. E., Eds., Thermal Analysis—Human Comfort—Indoor Environments, Proceedings of a Symposium held at the National Bureau of Standards, Gaithersburg, MD, Feb. 11, 1977, Nat. Bur. Stand. (U.S.), Spec. Publ. 491, 197 pages (Sept. 1977) Stock No. 003-003-01849-0, $3.25.

Environmental Studies: Pollution Measurement

Kirchhoff, W. H., Ed., Methods and Standards for Environmental Measurement. Proceedings of the 8th Materials Research Symposium held at the National Bureau of Standards, Gaithersburg, MD, Sept. 20-24, 1976, Nat. Bur. Stand. (U.S.), Spec. Publ. 464, 659 pages (Nov. 1977) Stock No. 003-003-01704-3, $11.

Mavrodineanu, R., Ed., Procedures Used at the National Bureau of Standards to Determine Selected Trace Elements in Biological and Botanical Materials, Nat. Bur. Stand. (U.S.), Spec. Publ. 492, 295 pages (Nov. 1977) Stock No. 003-003-01858-9, $7.50.

Instrumentation and Experimental Methods

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NEWS BRIEFS

PROFESSIONAL TIME-TELLING. The National Bureau of Standards has published a new 210-page "how to do it" manual for making time and frequency calibrations. The Time and Frequency Users' Manual explains what services are available, how to use them, and what the disadvantages and advantages are of various calibration systems and methods in terms of cost, convenience, and accuracy. The manual is available from the Superintendent of Documents, U.S. G.P.O., Washington, D.C. 20402 as NBS Technical Note 695, Stock No. 003-003-01781-7 for $2.80.

MARSHALS SAVE ON RADIO GEAR. Adapting NBS-developed performance standards and applying them as a quality control yardstick, the U.S. Marshals Service recently contracted for purchase of 560 sending-receiving mobile radio units at savings expected to total more than one-half million dollars. Five NBS Law Enforcement Standards Laboratory standards were involved, covering mobile FM transmitters, receivers, and antennas, RF coaxial cable assemblies, and tone coded squelch.

DO WINDOWS WASTE ENERGY? Not necessarily, according to a recent NBS study of the thermal and lighting characteristics of two model situations. If natural daylight is taken advantage of and if windows are designed and operated properly--with thermal shutters used on winter nights and venetian blinds used on summer days, for instance--windows can actually reduce overall operating costs below those for windowless walls. However, the NBS report warns that if such "window management" measures and daylight are not used, windows can increase a building's heating and cooling requirements.

DOWNWARD TREND IN R&D EMPLOYMENT. The proportion of scientists and engineers employed in major industries in 1975 was lower than in the mid 1960's, indicating that technical functions were accorded less priority in these industries. This finding was reported in Reviews of Data on Science Resources, No. 30, "Scientific and Technical Personnel in Private Industry, 1960-70 and 1975" (NSF 78-302). Copies of the report are available from the Superintendent of Documents, U.S. G.P.O., Washington, D.C. 20550 for 80 cents a copy. Request Stock No. 038-000-00-361-5.

NEW STANDARD REFERENCE MATERIALS. Two cupro-nickel Standard Reference Materials (SRM's) are now available from the National Bureau of Standards. SRM 874, designated "high purity," has the residual content of trace elements of particular importance to the nuclear industry. SRM 875, designated "doped," has added amounts of these trace elements. Both SRM's are intended for use in chemical and instrumental methods of analysis. For additional information, write the Office of Standard Reference Materials, B311 Chemistry Building, NBS, Washington, D.C. 20234.

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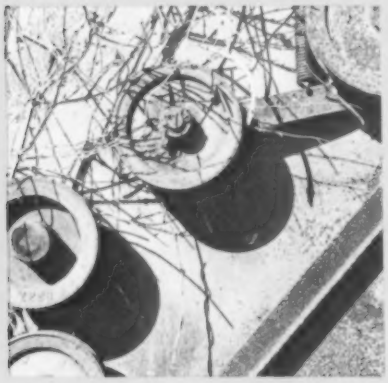

Any homeowner is aware that metallic corrosion—the gradual degradation and breakdown of metal under the attack of air, water chemical products, and pollutants—is an annoying and costly fact of life. Read about corrosion in the next issue of DIMENSIONS/NBS.

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